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ANNUAL REPORT

OF THE

BOARD OF REGENTS

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OF THE

SMITHSONIAN INSTITUTION,

SHOWING

THE OPERATIONS, EXPENDITURES, AND CONDITION
OF THE INSTITUTION

FOR

THE YEAR 1880.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1881.

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IN THE SENATE OF THE UNITED STATES,
February 3, 1881.

The following resolution was agreed to by the Senate, January 25, 1881, and concurred in by the House of Representatives, February 3, 1881:

Resolved by the Senate (the House of Representatives concurring), That fifteen thousand five hundred and sixty copies of the Report of the Smithsonian Institution for the year 1880 be printed; two thousand five hundred copies of which shall be for the use of the Senate, six thousand and sixty copies for the use of the House of Representatives, and seven thousand copies for the use of the Smithsonian Institution.

Attest:

JNO. C. BURCH,
Secretary.

LETTER

FROM THE

SECRETARY OF THE SMITHSONIAN INSTITUTION,

ACCOMPANYING

The annual report of the Board of Regents of that Institution for the year 1880.

JANUARY 19, 1881.—Ordered to be printed.

SMITHSONIAN INSTITUTION,
Washington, January 19, 1881.

GENTLEMEN: In behalf of the Board of Regents, I have the honor to submit to the Congress of the United States the annual report of the operations, expenditures, and condition of the Smithsonian Institution for the year 1880.

I have the honor to be, very respectfully, your obedient servant,

SPENCER F. BAIRD,
Secretary Smithsonian Institution.

Hon. WM. A. WHEELER,
President of the United States Senate, and
Hon. S. J. RANDALL,
Speaker of the House of Representatives.

THE SMITHSONIAN INSTITUTION.

MEMBERS EX OFFICIO OF THE "ESTABLISHMENT."

RUTHERFORD B. HAYES, President of the United States.
WILLIAM A. WHEELER, Vice-President of the United States.
MORRISON R. WAITE, Chief Justice of the United States.
WILLIAM M. EVARTS, Secretary of State.
JOHN SHERMAN, Secretary of the Treasury.
ALEX. RAMSEY, Secretary of War.
RICHARD W. THOMPSON, Secretary of the Navy.
HORACE MAYNARD, Postmaster-General.
CARL SCHURZ, Secretary of the Interior.
CHARLES DEVENS, Attorney-General.
EDGAR M. MARBLE, Commissioner of Patents.

REGENTS OF THE INSTITUTION.

MORRISON R. WAITE, Chief Justice of the United States, *President of the Board.*
WILLIAM A. WHEELER, Vice-President of the United States.
HANNIBAL HAMLIN, member of the Senate of the United States.
NEWTON BOOTH, member of the Senate of the United States.
ROBERT E. WITHERS, member of the Senate of the United States.
HIESTER CLYMER, member of the House of Representatives.
JAMES A. GARFIELD, member of the House of Representatives.
JOSEPH E. JOHNSTON, member of the House of Representatives.
JOHN MACLEAN, citizen of New Jersey.
PETER PARKER, citizen of Washington, D. C.
ASA GRAY, citizen of Massachusetts.
HENRY COPPÉE, citizen of Pennsylvania.
WILLIAM T. SHERMAN, citizen of Washington, D. C.
NOAH PORTER, citizen of Connecticut.

Executive Committee of the Board of Regents.

PETER PARKER. JOHN MACLEAN. WILLIAM T. SHERMAN.

OFFICERS OF THE INSTITUTION.

RUTHERFORD B. HAYES, President of the United States, *ex officio* Presiding Officer.
MORRISON R. WAITE, Chief Justice of the United States, Chancellor of the Institution (President of the Board of Regents).
SPENCER F. BAIRD, Secretary (Director of the Smithsonian Institution and of the National Museum).
WILLIAM J. RHEES, Chief Clerk.

OFFICERS AND ASSISTANTS OF THE SMITHSONIAN INSTITUTION AND NATIONAL MUSEUM, JANUARY, 1881.

SMITHSONIAN INSTITUTION.

SPENCER F. BAIRD,
Secretary, Director of the Institution.
WILLIAM J. RHEES, *Chief Clerk.*
DANIEL LEECH, *Corresponding Clerk.*

Assistants and Clerks.

CLARENCE B. YOUNG.
H. DIEBITSCH.
W. W. KARR.
J. A. TURNER.
L. STOERZER.
HENRY GASS.
WM. B. TAYLOR.
G. H. BOEHMER.
M. E. GRIFFIN.
H. DE C. DAINGERFIELD.
S. G. BROWN.
J. S. POLLOCK.

NATIONAL MUSEUM.

SPENCER F. BAIRD, *Director.*
G. BROWN GOODE, *Assistant Director.*
ROBT. RIDGWAY, *Curator* (*Ornithology*).
CHAS. RAU, *Curator* (*Archæology*).
TARLETON H. BEAN, *Curator* (*Ichthyology*).
CHARLES A. WHITE, *Curator* (*Paleontology*).
GEORGE W. HAWES, *Curator* (*Mineralogy*).
F. W. TAYLOR, *Chemist.*
EDWARD FOREMAN, *Assistant* (*Ethnology*).
F. H. CUSHING *Assistant* (*Ethnology*).

HENRY HORAN, *Superintendent of Building.*
C. W. SCHUERMANN, *Assistant.*
ALBERT A. DULY, *Engineer.*
W. J. GREEN, *Electrician.*
JOSEPH PALMER, *Modeller.*
A. Z. SHINDLER, *Artist.*
T. W. SMILLIE, *Photographer.*
HENRY MARSHALL, *Taxidermist.*
S. C. BROWN, *Registrar.*
E. P. UPHAM, *Clerk* (*Archæology*).
F. R. SCHAEFFER, *Copyist.*
JOSEPH HERRON, *Janitor.*

ANNUAL REPORT OF THE SMITHSONIAN INSTITUTION FOR THE YEAR 1880.

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2. Report of the Executive Committee, exhibiting the financial affairs of the Institution, including a statement of the Smithson fund, the receipts and expenditures for the year 1880, and the estimates for 1881.
3. Proceedings of the Board of Regents for the session of January, 1881
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REPORT OF PROFESSOR BAIRD,

SECRETARY OF THE SMITHSONIAN INSTITUTION, FOR 1880.

To the Board of Regents of the Smithsonian Institution:

GENTLEMEN: I have the honor to present herewith a report of the condition of the Smithsonian Institution for the year 1880.

As heretofore, in addition to matters pertaining strictly to the Smithsonian Institution, I shall give an account of the operations connected with the National Museum, placed by Congress in charge of the Smithsonian Institution, as well as of those of the United States Fish Commission, of which the present Secretary is the chief officer.

THE SMITHSONIAN INSTITUTION.

INTRODUCTORY.

In the report for 1879 the announcement was made of an appropriation by Congress for the purpose of constructing a new building for the service of the National Museum, and of the commencement and rapid progress of the work upon the same. I now have the pleasure of stating that the work has been in the greater part completed during the year 1880, and that a portion of the building is already occupied for its legitimate objects.

The details of progress and completion will be given in full in the report of the building committee and of the architect, to which I would refer. It will be sufficient to say here that the work has all been done within the estimates, and that it promises to be even more suitable to its purpose than was anticipated. All the requirements in regard to light and heat are fully met; and in this respect, and in that of its slight cost in proportion to the space obtained, the building is believed to have no parallel in the country. Including the building proper, the steam heating apparatus, the gas and water fixtures, and all their accessories, the cost has amounted to less than $3 per square foot of ground floor, and to about 6 cents per cubic foot of entire capacity.

Another noteworthy event of the year has been the election of Mr. James A. Garfield, one of the Regents of the Institution, to the office of President of the United States.

MEMORIALS.

Statue of Professor Henry.—The annual meeting of the Board of Regents was held on the 17th of January, at which time the usual reports of the year 1879 were presented. Prior to that date a bill had been introduced into the Senate by Mr. Booth, a Regent of the Institution, providing for the erection in the grounds of the Smithsonian Institution of a statue of Professor Henry. This, in a somewhat modified form, passed the Senate and House and became a law by the signature of the President on the 1st of June, 1880.*

The total appropriation was $15,000, and it was agreed that one-fourth should be paid on the completion of the design, one-fourth on the completion of the model in clay, one-fourth on the completion in bronze, and the remainder on the placing of the statue in the Smithsonian grounds.

Memorial representations of Professor Henry.—The Institution is indebted to Mr. F. Gutekunst, of Philadelphia, for copies of an excellent phototype of the late Secretary, Professor Henry, copied from a photograph taken by the same artist during the time of the Centennial Exhibition. The portrait is a mechanical imprint of cabinet size, a close reproduction of the original photograph.

Although a partial account of various portraitures of Professor Henry was given in the last annual report, it may not be improper, with the view of making the record more complete, to repeat those formerly mentioned, as well as to indicate additional likenesses.

Of original *photographs*, there are one small front face (carte size) by H. Ulke; one profile head (carte size) by T. W. Smillie; one small size, full-length, standing, by the same; one front view of head and bust, cabinet size, by the same, and one, imperial size, by the same; one, carte size, and four different views, cabinet size, by M. B. Brady, of Washington; two, cabinet size, by A. Gardner, of Washington; three, cabinet size, by S. M. Fassett, of Washington; and one of cabinet size and one of imperial size, both by F. Gutekunst, of Philadelphia.

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* In view of the adjournment of the Board of Regents at the time of the passage of the law, it was impossible to take any formal action in the matter; but in the exercise of its general discretion, the executive committee entered into correspondence with Mr. Story, the artist designated in the act as the sculptor, and obtained from him his acceptance of the trust, and some suggestions as to the design and the general conditions of carrying it out.

As the executive committee was doubtful as to its authority to carry out fully the provisions of the proposed agreement with Mr. Story, the members of the Board were communicated with by letter and their assent obtained to such action as the committee might deem best in the premises.

It was therefore thought best to make a provisional ratification of the agreement with Mr. Story, the session of Congress in the beginning of December rendering it possible to obtain the action of the Board before anything could be done by the sculptor. A meeting of the Board therefore, was held on the 8th day of December, 1880, and the action of the executive committee was approved and authority given to carry it into effect. A dispatch was sent by Atlantic cable to Mr. Story, and the work, according to a recent communication from Hon. George P. Marsh, United States minister at Rome, Mr. Story's place of residence, is progressing satisfactorily.

Of *crayon* heads of life size, there are one by H. Ulke, from an oil portrait by the same; one by Mrs. Fassett, from a portrait by S. M. Fassett; one by Mrs. M. G. Dayton, from a photograph by Fassett; one by R. Reichmann, from a photograph by T. W. Smillie; and one by A. J. Janvier, from a photograph by M. B. Brady.

Of *wood-cuts*, one was published in an "Account of the Smithsonian Institution," by W. J. Rhees, Washington, 1855; and one in Harper's Weekly of June 1, 1878, accompanying an obituary notice.

Of *engravings* on steel, one was produced by L. L. Punderson, from a painting by Mooney, and published at Boston in the Annual of Scientific Discovery for 1852; one was engraved by G. R. Hall, from a photograph, and published at New York in the Eclectic Magazine for March, 1875; one was engraved by S. Hollyer, from a photograph, and published at New York, in Appleton's Annual Cyclopedia for 1879; and one of small size, vignette, was engraved by the Bureau of Engraving and Printing of the Treasury Department, at Washington, 1880, for publication in the Memorial volume ordered by Congress.

Of *oil paintings*, of bust or half-length life size, one was painted by H. Ulke, of Washington; one was painted by W. Ingalls; one by Thomas Le Clear, of New York; and one by Theodore Kaufmann, of Washington.

Of *busts in plaster*, one of small size was modeled by C. W. Burton, of Washington; one of life size by Clarke Mills, of Washington; one of life size by Fisk Mills, of Washington; and one of life size by Mrs. C. S. Brooks, of New York.

In the last report it was stated that Congress had authorized the printing in one volume of the memorial services held in honor of Professor Henry in the House of Representatives on the 16th of January, 1879. Of this volume a large edition was ordered; and after various delays, beyond the control of the Institution, it will soon appear in a well-printed form, accompanied by an excellent portrait engraved by the Treasury Department. There has been a great demand for this work from all quarters of the country, and copies of it will be placed in all the principal libraries at home and abroad.

Smithson's Effects.—By the 6th section of the organizing act of Congress of August, 1846, it was provided that "the minerals, books, manuscripts, and other property of James Smithson, which have been received by the Government of the United States, and are now placed in the Department of State, shall be removed to said Institution, and shall be preserved separate and apart from other property of the Institution."

The books belonging to the founder of the Institution have been catalogued and placed in a handsome walnut case with plate-glass front. They consist of 45 duodecimo, 110 octavo, and 26 quarto volumes, many of them in a worn, and a few in a dilapidated condition. It has been thought proper, however, to leave them exactly as they were when forming the library of Mr. Smithson.

Such of the relics of Smithson and his family as have come into possession of the Institution have also been appropriately arranged in frames and placed on exibition in the Regents' room. They consist of the following articles:

1. An oil portrait of Smithson as an Oxford student.
2. An oil portrait in miniature of Smithson, painted by Johns, at Aix-la-Chapelle, in 1816.
3. An oil portrait in miniature of Col. Henry Louis Dickinson, a half-brother of James Smithson.
4. The dinner invitation card of Smithson.
5. His visiting card, used in Paris.
6. A copy of his will in his own handwriting.
7. A manuscript in his handwriting.
8. A commission from George III to Major Henry Louis Dickinson, as Lieutenant-Colonel, dated 1st Jan., 1800.
9. A commission from the same King to Lieut.-Colonel H. L. Dickinson, as Colonel of the 84th Regt., dated 4th Aug., 1808.

Smithson's Tomb.—It is, of course, eminently proper that the Smithsonian Institution should do all in its power to preserve the remembrance of its great founder, Mr. James Smithson; and an endeavor toward this end has been made by the publication of a Life of Smithson and a reprint of all his works. In the efforts to obtain a memorial of some kind of the last resting place of Mr. Smithson, at Genoa, in Italy, a photograph of the tomb was obtained from Mr. Hazelton, the United States consul in that city, with a statement of its present condition. In accordance with a suggestion from him he was authorized to put the monument in thorough repair and to arrange to have it kept in good condition at the expense of the Institution. The monument is an appropriate and substantial one, and as long as the Institution is in existence this reminder of its founder should be carefully protected.

INAUGURAL RECEPTION.

Reference should be made to the granting of the use of the new Museum building for the purpose of holding the inaugural reception in honor of the newly-elected President. A petition to that effect, from a committee of citizens of Washington, was presented at a meeting of the Board on the 8th of December, and the following resolution, granting the request, was passed:

"Whereas the new Museum building is unfinished and not ready for occupancy of the government collections, and whereas such a contingency will not again occur, and no precedent is to be given for the use of the building for other purposes:

"*Resolved*, That the use of the new National Museum building be granted for the inaugural reception of the President of the United States, on the 4th of March, 1881, and that the Secretary of the Smithsonian Institution be authorized to make all necessary arrangements for this purpose."

Subsequently application was made to the Institution by several other committees for the use of the building after the inaugural reception on the 4th of March. These were all refused, although the objects in view were praiseworthy in themselves.

FINANCES.

General Condition.—It is believed that the finances of the Institution have never been in amore favorable condition than they are at the present time.*

As the income of the Smithson fund is a definite one and can be calculated upon almost to a cent, year by year, it is, of course, practicable to estimate the expenditures with much precision. Nothing but some calamity, such as the destruction or serious injury of the building, is likely to involve an outlay that would seriously interfere with the general programme for the year.

Under the general limitations of the appropriations made by the Board of Regents, for the different classes of expenditure, it is, of course, a matter of proper business management to incur no liabilities for the year beyond those that the fund is able to meet; and a strict adherence to this rule has prevented any embarrassment in regard to payments. There has been no indebtedness at the end of the year except that for some incomplete publications, and for which the necessary provision had been made.

Reference has been made in this report to several bequests, by which the principal of the fund has been increased, the first of these being that of Mr. James Hamilton, of Carlisle, which, amounting to $1,000 was added to the principal of the Smithson fund in the United States Treasury.

Habel Bequest.—An account was given in the last report, of the bequest of $402.59 to the Smithsonian Institution by Dr. S. Habel, of New York. By authority of the executive committee, the sum of $97.41 was appropriated from the annual income of the Institution and added to the above in order to make up the amount of $500. This was then deposited in the United States Treasury to the credit of the Smithsonian endowment, under the provisions of law.

The Habel bequest thus slightly enlarged and added to the Hamilton fund of $1,000, making the sum of $1,500, will yield annually at 6 per cent. an income of $90. It is proposed to devote this special income to the prosecution of ethnological and archæological research.

The funds of the Institution now in the treasury, according to the report of the executive committee, amount, with these two bequests, to

---

*The endowment (referred to elsewhere) is for the most part in the U. S. Treasury, where the principal can never be touched, and it yields an annual interest of six per cent. A small portion is invested in Virginia State securities.

$651,500, leaving a balance of $348,500 necessary to make up the million dollars authorized by Congress as its perpetual endowment. It is very much to be hoped that some of our wealthy men may feel inclined to contribute a part or even the whole of this sum, as it is believed that no more desirable contribution to science and education could be devised. The machinery of the Institution is extensive enough to administer a much larger amount than it at present possesses, so that no part of such contribution would be required for salaries, rent, or other attendant expenses. It may safely be said that the addition of one-half to the present fund would at least double the efficiency of the Institution in carrying out its mission of the "increase and diffusion of knowledge among men."

Relation to the National Museum.—It is, of course, fully understood that while the Smithsonian Institution is supported and administered at the expense of the Smithson endowment, the cost of carrying on the National Museum is necessarily defrayed entirely by Congressional appropriations. Although the estimates presented by the Institution from time to time as desirable for the prosecution of the work have sometimes been reduced by the Congressional committees, there is no reason to complain of the feeling of Congress toward this interest, and it is confidently believed that as the plans in regard to the reorganization of the Museum in the new building are carried out a cordial support will be extended in the future. The appropriations required for the maintenance of an establishment five times as great as the present one must necessarily be largely increased, although not in proportion to its expansion. It is evident that to supply a building covering two and a half acres of ground with cases will require a large expenditure of money until they are completed. It is estimated that the cases needed will in a continuous line extend a mile and a half; and of course several years will be required for their proper construction. After this the cost of the Museum will be essentially that of maintenance only, and be reduced much below the figures for the fiscal year of 1881.

BUILDINGS.

Smithsonian Building.—The disastrous fire which destroyed a large portion of the roof and upper story of the Patent Office building in the summer of 1877, gave rise to the formation of a commission of government officers, consisting of Col. Thomas L. Casey, Mr. E. Clark, and Mr. J. G. Hill, to inspect all buildings of the government in the city, and to report what measures might be necessary to better secure them and their contents from injury by fire. The Smithsonian building was one of those carefully examined by the commission, and it was recommended that iron doors should be placed in the passage ways between certain rooms. An appropriation of $3,000 was subsequently made by Congress for this purpose; and a contract for its execution was accordingly entered into with Mr. George L. Damon, of Boston. After considerable delay in the performance of this contract, the doors were delivered and put in place by Mr. Damon, to the entire satisfaction of the executive committee. This arrangement has greatly promoted the safety of the building and its contents from the risk of the spreading of any fires which might accidentally occur within its walls. A few additional changes are still desirable to give still further security to the public property placed in the charge of the Institution.

For the purpose of facilitating the operations of the freight and transportation department of the Institution, an elevator was constructed in 1879, by which packages could be carried from the southeastern entrance of the building, either to the basement floor below, or to the document room above. During 1880, the work has been completed by the erection of a very substantial platform outside of the door, on which boxes can be conveniently delivered, or from which they can be shipped. From the rapidly increasing amount of transportation connected with the natural history operations and the scientific exchanges, every facility in the handling of packages, by economizing labor, becomes an item of importance.

For many years a pump at the southeastern corner of the Smithsonian building has furnished a supply of excellent water, esteemed throughout the neighborhood. Although the introduction of the Potomac water naturally reduced considerably the demand upon this pump it was still constantly drawn upon by persons passing by, and was used for supplying the water-coolers in the building. A chemical and microscopic examination of the water made during the summer showed that it was not entirely wholesome, in consequence as was thought, of the rotting of the inner wooden lining of the well. As a necessary step to the improvement of the sanitary condition of the water the original lining was replaced by one of brick. An iron pump was also substituted for the former wooden one. These repairs have been satisfactorily completed, and the water is now restored to its original quality.

The protection of the buildings in charge of the Smithsonian Institution and the preservation of the property contained therein require, of course, the vigilance of competent watchmen, both day and night. One of these, Mr. T. S. Nelligar, a night watchman in the new museum building, has been made a special policeman by the Board of police.

The situation of the Smithsonian building, so far to the south of the principal avenues of travel in Washington, renders it somewhat inconvenient of access, especially during inclement weather. At present the nearest street railways are those along Seventh street and along Twelfth street. The completion of the new building for the accommodation of the Bureau of Engraving and Printing of the Treasury Department, on South B street (at the corner of Fourteenth street), as also of the new National Museum building, on the same street (near Ninth street), occasioning a large increase of travel in that direction, induced the proprietors of the so-called "Belt Line" of railway to memorialize Congress for permission to change the track of their road by extending it down Fourteenth street to South B street, thence along South B street past the entrance to the National Museum, and thence south along Ninth street to Maryland avenue, along which it now passes. Congress has not yet taken any action on this memorial. Should that body authorize the proposed change of route it will add greatly to the convenience of all who are interested in that line of travel.

Armory Building.—The Armory building is still in use as the depository of the Centennial and other collections belonging to the government. These articles will be removed to the new Museum during the present year, but as there is no provision in this building for storage of boxes, packing materials, &c., a part of the Armory will always be required for this purpose. It is also contemplated to use one of the halls or stories of the Armory for the storage of the large amount of property belonging to the United States Fish Commission, and the lower floor may perhaps be occupied by aquaria, hatching apparatus, &c.

Laboratory of Natural History.—The building erected as a laboratory of natural history and a photographic atelier in which to prepare specimens, illustrations, &c., for the Centennial Exhibition is still devoted to similar uses. A large number of photographs of fish, ethnologica, &c., have been made during the year by the artist of the Institution, Mr. T. W. Smillie.

Mr. Joseph Palmer and his son have continued in this building the preparation of plaster casts of fish, reptiles, and antiquities, and in another apartment these have been colored by the artist, Mr. A. Z. Shindler, the reproductions thus furnished being admirable fac-similes of the living or original objects, and attracting general commendation.

Another large room occupied by Mr. Henry Marshall, the taxidermist, has mainly been devoted to the mounting of birds and mammals.

In the new Museum building very commodious apartments have been assigned to the photographer and other artists, a large and well arranged sky-light has been provided, and everything will be done by the Institution to secure the best possible results with all the apparatus and appliances obtainable. To obtain ample working rooms in case of an emergency, however, the tanks, dark-room, sky-light, &c., in the old building will be left undisturbed so that if necessary an extra force of photographers may be enabled to carry on their work.

ROUTINE WORK OF THE INSTITUTION.

Administration.—No change has been made in the officers and assistants of the Institution since the death of the late Secretary. Mr. William J. Rhees, who has been chief clerk since June, 1853, still discharges the duties of executive officer with zeal, industry, and efficiency. During the absence of the Secretary for several months in the year, when on duty connected with the United States Fish Commission, Mr. Rhees has been intrusted with the general administration of the business of the Institution; having also the charge of publications, of financial details, of the purchase of supplies, and of the supervision of clerks and employés, &c. The operations connected with the erection of the new Museum building have added greatly to the labors and responsibilities of the chief clerk, as well as of the other officers of the Institution.

The correspondence is in charge of Mr. Daniel Leech, who has been in the Institution since 1867, and who has also acted as the secretary of the National Museum Building Commission. In both these relations his duties have been satisfactorily and creditably performed.

The division of accounts has been in charge of Mr. Clarence B. Young, who entered the service of the Institution in 1870. To his duties as bookkeeper is added that of the charge of the physical apparatus, the revision of proof, mathematical calculations, and other work requiring skill as a computer, and knowledge of physics and technology.

To Mr. Wm. B. Taylor has been assigned the duty of preparing replies to correspondents involving scientific details in special departments; and he has also edited—under the direction of the special committee of the Board of Regents—the "Memorial Volume" in honor of Professor Henry.

The management of the literary and scientific exchanges has been intrusted to Messrs. H. Diebitsch and G. H. Boehmer. The labor in this department has grown to large proportions, and is increasing with every year.

The reception, entry, and transfer of books for the library are in charge of Miss Jane A. Turner, whose faithful and intelligent services have frequently been recognized by my predecessor.

The translation of French and German letters and various clerical duties have been well performed by Mrs. L. Stoerzer, while the filing of letters, indexing, making out receipts and orders for books, and various other duties have been assigned to Miss M. E. Griffin, Miss H. de C. Daingerfield, and Miss F. R. Schaeffer, who deserve commendation for their faithful services.

It is also proper to mention the fidelity and efficiency in the subordinate duties assigned them of Messrs. Henry Gass and John S. Pollock. Mr. Solomon G. Brown, in charge of the transportation department, has discharged his duties satisfactorily.

Correspondence.—A most important branch of Smithsonian operations is that of correspondence, which expands from year to year in the direct ratio of the ever widening influence and increasing activity of the establishment. The principal consideration, however, in this department, is not the amount but the continuity of the labor involved, since the rules of the Institution, while they insure a respectful reply to all communications demanding an answer, also require that each day's mail shall be attended to on the day of its receipt, excepting where immediate action is impracticable. In other departments of the Institution, as, for instance, that of publications, operations being more or less dependent upon outside agencies, there is sometimes a temporary respite; but in the department of correspondence this is absolutely impossible.

As during the past three years, so during 1880, the number of communications has been very great in regard to anthropology, natural history, mineralogy, exchanges, employment, and publications. In regard to the first of these the immediate cause has been the unprecedented interest awakened in the subject of anthropology by the Smithsonian circular to which attention was called in the report of the Secretary for 1878.

As the near completion and occupation of the new building for the National Museum has become generally known, hundreds of colleges, as well as proprietors of private collections, aware that the Institution has only awaited the room requisite for the collation of its vast stores of specimens of natural history and the elimination of the duplicates previous to the distribution of the latter, have hastened to apply for a share in this material, the applications in almost every instance necessitating answer by reason of inquiries for information upon points not covered by any of the many printed circulars of the Institution.

In mineralogy the number of applicants for information has largely increased during the past year. Supposed discoveries of mineral wealth still continue to be reported to the Institution, and specimens are forwarded for examination. Qualitative determinations only, however, are made gratuitously for individuals or for private or commercial purposes; but these generally suffice. In making known the results of mineral examinations the mineralogist presents his reports to the Secretary, on blanks prepared for the purpose. If approved the substance of his report is communicated by letter to the party submitting the specimens.

The increased activity in the department of exchanges has not only continued, but this source of correspondence has during the past year proved far more productive of communications than was anticipated; and while the increase in the number of these has been marked, in very many instances their nature has been such as to call for a general review of the entire subject of exchanges, thus giving to the replies, on the part of the Institution, the character more of memoirs than of letters. This feature of a large part of the exchange correspondence grew out of the action of the Paris Geographical Congress of 1875, in recommending to the nations of the world the establishment of a system for the interchange of the official documents of their respective governments, which recommendation has recently been favorably acted upon by a number of governments, including the United States, which has designated the Smithsonian Institution as its agent in the premises.

With reference to applications for employment, it may be said that while in no single year of its history could the Institution claim entire exemption from the receipt of this class of communications, the year 1880 marks an epoch in this respect as being the period in which the maximum number has claimed attention. Indeed, it is far from an exaggeration to say that written and oral applications of this kind have averaged half a dozen a day. As a majority of those in writing are in the nature of requests through members of Congress, or other persons of prominence, a double answer frequently becomes necessary, one to the applicant and a second to the party through whom the claim is presented, the latter generally necessitating a detailed explanation of the cause for the refusal.

Lastly, an important part of the correspondence consists in the constantly increasing demands for the Smithsonian publications. With the increase of popular education throughout the land, and the springing up of new villages or towns, new public libraries and scientific societies are started, and very soon an application is made to the Smithsonian Institution for its publications. Applications of this kind are required to be entered on printed forms, and forwarded through the member of Congress representing the district in which the establishment is located, the member thus becoming sponsor for the library or society, so far as its existence and standing are concerned.

The requests from individuals for publications, however, are not infrequently difficult to deal with. In a country where all are equal it is sometimes difficult to satisfactorily explain why each individual cannot receive this or that publication gratis. It is often useless to state that the publications of the Institution are issued at the expense of *its own* fund, and not at that of the general government; that this fund is so limited as to forbid the issuing of more than a comparatively small number of copies; that with these both hemispheres must be supplied; that they are distributed free of expense to public libraries and colleges throughout the country on condition that they shall be accessible at all times to any who may desire to consult them; that to individuals, other than specialists and contributors of material for the national collections, they are sold at about the cost of paper and printing; or, that the desired memoir, or memoirs, will be cheerfully furnished in return for desirable objects for the National Museum. It might reasonably be supposed that a statement of this character would prove satisfactory; but, unfortunately, this has not been our experience, such a result being the exception, not the rule, and shortly the demand is renewed through the member of Congress from the district in which the applicant resides.

ASTRONOMICAL ANNOUNCEMENTS BY TELEGRAPH.

The existing arrangements for disseminating telegraphic announcements of astronomical discoveries, particularly between America and

Europe, were set forth in the last report. This Institution is the center of diffusion throughout our own country, of astronomical announcements received by telegraph from foreign countries, and in like manner acts as the medium of communication of American discoveries through Atlantic cables to the European observatories of Greenwich, Paris, Berlin, Vienna, and Pulkova; from which points the information is spread throughout their respective countries. Through the courtesy of various telegraph companies, the information received from abroad is transmitted to the principal observatories (some seventeen in number) throughout the United States, and also to the "Associated Press," free of charge. This generous concession to the urgent needs of astronomical research and progress is so valuable a boon to science that it should annually receive a grateful and public acknowledgment. The companies to whose liberality we are thus indebted are: The Atlantic Cable Company, The United States Cable Company, The Pacific Cable Company, The Western Union Telegraph Company. To these must be added the Northwestern Telegraph Company, which gives gratuitous transmission of astronomical telegrams to Northfield, Minn.

Prof. B. A. Gould, the eminent superintendent of the observatory of Cordoba, of the Argentine Republic, when making a visit lately to the United States on his way to Europe, had some conference with several leading astronomers respecting certain proposed improvements in the exchange of telegrams, and of the character of the abbreviations to be employed. These suggestions, presented to the Institution, were by it embodied in a circular, which was referred to the directors of the different observatories scattered over our country soliciting their opinion as to the desirability of the changes proposed. Dr. C. H. F. Peters, of the observatory at Clinton, N. Y., to whom the original suggestion of telegraphic announcement is mainly due, was particularly desired to give the subject his consideration. When the various responses to these circulars of inquiry are received, it is intended to have them carefully considered by a commission of astronomers, and the formulas which appear to meet the general approval will be finally adopted as the uniform and permanent method of designation.

The announcements of astronomical discoveries made during the past year are as follows:

List of minor planets discovered in 1880.

No.	Name.	Date.	Discoverer.	Discoverer's No.	Observatory.
212	....	Feb. 6	Palisa	25th.	Pola.
213	Lilæa	Feb. 17	Peters	41st.	Clinton.
214	....	Mar. 1	Palisa	26th.	Pola.
215	Œnone	Apr. 7	Knorre	2nd.	Berlin.
216	....	Apr. 10	Palisa	26th.	Pola.
217	....	Aug. 30	Coggia	4th.	Marseilles.
218	....	Sept. 4	Palisa	27th.	Pola.
219	....	Sept, 30	Palisa	27th.	Pola.

List of comets observed in 1880.

No.	Name.	Date.	Discoverer.	Discoverer's No.	Observatory.
A ..	Comet I..........	Feb. 1	Gill	....	Cape Town, Africa.
B ..	Comet II.........	Apr. 6	J. M. Schæberle	....	Ann Arbor.
C ..	Faye's comet	Aug. 2	A. A. Common..	....	Ealing, England.
D ..	Comet IV	Sept. 29	Hartwig	....	Strassburg.
E ..	Comet (1869, III).	Oct. 10	L. Swift	....	Warner Observatory.
F ..	Comet V	Dec. ..	Dr Pechule	....	Copenhagen.

An arrangement in regard to the exchange of telegrams of astronomical discoveries was proposed by Lord Lindsay in connection with the working of his private observatory of Dun Echt, in Scotland, and the Institution was invited to exchange therewith telegraphic communications in regard to the discovery of comets and asteroids. After further conference with the director in charge of the observatory of Greenwich it was concluded that dispatches sent to the latter would answer all the purposes by simply providing for the prompt repetition of these dispatches from Greenwich to Dun Echt.

EXCHANGES.

International Exchanges.—The system of international exchanges which has been successfully prosecuted for thirty years may be regarded as having been inaugurated by this Institution. A method of exchange had indeed been carried on for some years previously by Mr. Alexander Vattemare, of Paris, France, but on essentially different principles. Mr. Vattemare's plan consisted in obtaining duplicate volumes and contributions from booksellers, literary and scientific societies, public libraries, and other sources, and then from the collected mass making to his various contributors returns, at his own discretion, of what appeared to him a fair equivalent. Such a method of course presupposed a great familiarity with the actual possessions of the various bodies in correspondence, as well as of their needs; and while undoubtedly beneficial in some cases, was likely to be entirely unsuccessful in others.

The Smithsonian system consists substantially in offering to correspondents a safe and gratuitous channel of intercommunication, each being responsible to the other for the amount and character or value of the packages interchanged, the Institution assuming, between them, only the relation or function of carrier. It naturally happens, however, not unfrequently, that the Institution is requested to designate suitable parties to whom publications of a particular character should be sent. Such a request is responded to, either by furnishing such lists of names or societies as may be supposed to be desirable, or by undertaking the actual assignment of such works as are submitted to its discretion, during the process of making up its own packages.

Attention has frequently been called in previous reports to the steadily increasing expense attending this system of international exchanges. The cost of prosecuting various researches and investigations and the general expenses of the Institution being provided for, the residue of the income has usually been divided between the department of publications and that of international exchanges. So long as the latter interest required the expenditure of but a few thousand dollars, a considerable amount was available for the former, and the Institution was thus in a condition to publish many important memoirs; but of late years the cost of maintaining the exchange system has increased at so rapid a rate (the expense for 1879 and 1880 having reached nearly $10,000 each year) that only an inadequate and continually decreasing balance is available for the very important department of publication of original contributions to knowledge.

The official designation of the Smithsonian Institution by the State Department, as the American agent of international exchange has naturally, with the rapid extension of its operations, also added considerably to the burden of expense.

In view of these circumstances, a communication was addressed to the honorable Secretary of State, some months ago, by the Secretary of the Institution, asking that an application be made to Congress for a special appropriation toward defraying the expenses of international exchanges, to be disbursed under the direction of the State Department. This favor has been promised, and it is hoped that the desired relief will be granted.

As a result of the convention already referred to as held in Paris a few years ago, for promoting international exchanges between the various governments of the world, the interest and exertions in this direction are slowly extending. In addition to the commissions and bureaus of Belgium, France, Holland, and the Confederacy of Switzerland, mentioned in the last report as co-operating with the United States government, the Government of Brazil has since been included in the movement, and arrangements between it and the Institution have been satisfactorily adopted. A disposition to co-operate in this work has also been expressed by the Governments of Russia and of Italy, but no definite arrangements have as yet been concluded by them.

The interchange of scientific publications between the United States and Cuba has for a number of years been effected through the agency of Prof. Felipe Poey, of the University of Havana; and to that eminent naturalist, for both the extent and the efficiency of his labors, this Institution is greatly indebted. As the packages transmitted have been addressed to Professor Poey, questions have constantly arisen as to the duties charged to the Institution, in addition to the other cost of the enterprise. As it was thought unjust that the Smithsonian fund should be taxed with the entire expenses of this interchange, in both directions, while the main benefits of the transactions were experienced by Cuba, the subject was referred to his excellency Señor Don Felipe Mendez de Vigo, minister from Spain; through whose courteous efforts, a very satisfactory arrangement has been effected, whereby the governor-general of Cuba, in his official capacity, takes charge of our packages and delivers them to the University of Havana for distribution to their respective addresses. This arrangement constitutes in effect an additional link in the chain of international government agencies already referred to.

The total number of establishments outside of the United States with which correspondence and exchange have been conducted amounts to 2,602—an increase of about 120 over the list of 1879. The number of packages received from Europe for distribution in the United States during the past year amounted to 6,670; the number of packages from the United States received for transmission abroad has amounted to 14,175; making an aggregate of 20,845 packages.

The parcels received from Europe for distribution in America are generally forwarded to their respective destinations in smaller bundles, or in paper wrappers. The parcels received for transmission to foreign countries are carefully packed in boxes. Of these, there were shipped during the past year 268; occupying a bulk of 1,976 cubic feet, and weighing 60,300 pounds.

As heretofore, the Institution is greatly indebted to the lines of ocean steamers between the United States and other countries of the world; and grateful acknowledgment is due particularly to the agents of the following companies for the continuation of their important favors in the free transmission of Smithsonian packages: Anchor Steamship Company, Atlas Steamship Company, Compagnie Générale Transatlantique, Cunard Steamship Company, Hamburg American Packet Company, Inman Steamship Company, Merchants' Line of Steamers, Netherlands American Steam Navigation Company, New York and Brazil Steamship Company, New York and Mexico Steamship Company, North German Lloyds Steamship Company, Pacific Mail Steamship Company, Pacific Steam Navigation Company, Panama Railroad Company, Steamship Lines for Brazil, Texas, Florida, and Nassau, N. P., White Cross Line of Antwerp.

The railroad companies connecting Washington and Baltimore and New York have also continued their favor of special rates of charges for freight. These are the Pennsylvania Railroad, the Baltimore and Ohio Railroad, and the Baltimore and Potomac Railroad.

Acknowledgments are also due to the foreign ministers and consuls of the various governments, for their assistance in taking charge of the packages intended for the countries which they respectively represent, and transmitting them with care to their destination.

In connection with the establishment of definite relations between this Institution and the French commission of international exchanges (a branch of the department of the ministry of public instruction), the French Transatlantic Steamship Company has, through its agent, M.

Louis de Bebian, very generously agreed to carry the packages of exchange both ways free of charge, thus relieving parties on either side from a considerable burden, and greatly facilitating these operations.

Statistics of exchanges during the last ten years.

	1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.
Number of boxes.	108	179	196	131	208	323	397	309	311	*268
Bulk in cubic feet.	772	954	1,476	933	1,503	2,261	2,779	2,160	2,177	1,976
Weight.......lbs.	28,950	26,850	44,236	27,990	45,300	80,750	99,250	69.220	69,975	60,300

Foreign institutions in correspondence with the Smithsonian Institution.

Africa	27
America	112
Asia	60
Australia	64
Europe	2,337
Polynesia	2
	†2,602

Comparative table of foreign institutions in correspondence with the Smithsonian Institution during the last ten years.

1871.	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.
1,937	1,985	2,145	2,146	2,207	2,275	2,330	2,333	2,481	2,602

Parcels received in 1880.

For home distribution	6,670
For distribution abroad	14,175
Total	20,845

Government Document Exchange.—In addition to its general function of intermediary between the institutions of the New World and the Old, the Smithsonian Institution has been for some years the agent of the government for the exchange of public documents and other official publications, in the interest of the Library of Congress, and under the provisions of law. By act of Congress, fifty copies of all publications of the United States Government, whether ordered for the use of Congress or of the departments, are available for distribution, under the direction of the Joint Library Committee of the two Houses of Congress, to such foreign governments as agree to make a corresponding return. These returns, when received, are forwarded directly to the Library of Congress, without being entered on the records of this Institution. A detailed report in an appendix, gives all the information possessed under this head, including the aggregate of such distribution, the agencies through which it has been effected, and the parties interested in the exchange.

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* In addition to the above there are 26 boxes ready for and awaiting shipment to Italy.

† A detailed list will be found in the tables of statistics.

List of governments in exchange with the Government of the United States, and to whom box "N" was sent in 1880.*

Argentine Confederation.
Bavaria.
Belgium.
Brazil.
Buenos Ayres.
Canada.
Chile.
Denmark.
France.
Germany.
Greece.
Würtemberg.
Hayti.
Japan.
Mexico.
Netherlands.
New South Wales.
New Zealand.
Norway.
Ontario (Canada).
Portugal.
Prussia.
Queensland.
Saxony.
Spain.
Sweden.
Switzerland.
South Australia.
Tasmania.
Turkey.
Venezuela.
Victoria.

DISTRIBUTION.

Distribution of Publications.—One of the operations of the Institution requiring constant attention and involving much labor and expense is that of distribution of publications. Aside from the sending of books and parcels through the great international exchange system there is a constant demand upon the institution for works it has published or those of a scientific character supposed to be at its disposal. These demands have become so numerous and are made by so many persons unknown to the officers, while the supply of books is so limited, that it became necessary to adopt a new rule in reference to distribution. Each applicant is now required to furnish evidence that he has contributed in some way to the library, museum, or collections of the Institution, and an exchange is thus established, intended to supersede the former promiscuous method of bestowing a gift. It may be mentioned that latterly no lists have been kept of persons entitled to receive from year to year the publications or even the reports of the Institution. It is necessary that direct application be made by each person for any work desired.

Distribution of Specimens.—In view of the immense mass of material received at the National Museum from the various government expeditions and the geological survey, as well as from the contributions of correspondents, it will be readily understood that the duplicates have accumulated very rapidly for many years and that the proper disposal of this surplus has occupied the attention of the Smithsonian Institution.

Under the organic law the Institution is authorized to increase the collections of the National Museum by the exchange of duplicate specimens; but only a small amount is conveniently disposed of in this manner, and by far the greater proportion is issued without any expectation or desire for a return. The table appended to this Report will show what has been done up to date, as the distributions of the year 1880.

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* For the Government of Italy 13 boxes (A N) are ready for shipment.

The distributions indicated have represented a fair average for the year 1880. It is expected that in the year 1881, the amount will be vastly increased by the disposal of the Centennial collections, which have been so long stored in the Armory building, and which it is expected will soon be transferred to the new Museum building, just completed. These objects will be principally those relating to the mineral kingdom, the ores and building stones being in the largest proportion. Applications for collections from establishments not well known, are usually referred to the member of Congress in the district in which the applicant belongs, and an expression of opinion is invited as to the character and standing of the same.

As a general rule, no specimens are sent away without being authoritatively and accurately labeled by an expert, so that they become standards of reference.

LIBRARY.

The additions to the library of the Institution through its system of scientific exchanges, continue to be very large. During the past year, the books, pamphlets, and charts received, have amounted to 8,570 pieces; a portion of which consists of parts or continuations of volumes, such as the current proceedings and transactions of learned societies, and the accessions to established scientific journals. Making due allowance for such fragmentary continuations, the whole number of complete volumes may be estimated at 6,000 titles; of which by far the greater portion has been as usual transferred to the custody of the Library of Congress, where they constitute an important section of the great national collection.

In this statement is not included the large number of volumes received under the arrangement for international government exchanges, and sent directly to the Library of Congress without being opened or catalogued at the Institution.

Statement of the books, maps, and charts received by the Smithsonian Institution during the year 1880, *and transferred to the Library of Congress.*

Volumes:		
Octavo or smaller	806	
Quarto or larger	337	
		1,143
Parts of volumes:		
Octavo or smaller	2,577	
Quarto or larger	2,603	
		5,180

Pamphlets:		
Octavo or smaller	1,618	
Quarto or larger	477	
		2,095
Maps and charts		152
Total		8,570

The Institution has received from Mr. John T. Fisk, president of the American Industrial Deputation, at Puebla, Mexico, through his excellency the Mexican minister, a very handsomely bound volume of small size, of Prayers and Devotions, in the Spanish language. The binding of this book is quite unique, the sides and back being covered with highly polished plates of Mexican onyx, cemented upon a purple silk cover, which is exposed only in the groove forming the flexible joint between the sides and the back. The front plate (four and a half inches long, by two and seven-eighths inches wide, and probably about three-sixteenths of an inch at its middle, gently rounding and thinning toward its edges) is of a delicate mottled pink color, and is embellished with ornamental engraving filled in gilt. The corresponding plate forming the opposite cover is, of course, of exactly the same size; but it is of a delicate mottled green color: its ornamentation is similar to that of the front side, though of a different design. The back of this curious volume is entirely covered with a finely polished piece of delicately mottled blue Mexican onyx, without ornament, nearly one inch in width, which has been laboriously and skillfully hollowed out to conform to the rounded back of the volume. On the front fly-leaf of the book the following inscription is written: "The Very Rev. Monsignor Eulagio G. Gillou, domestic prelate of the Pope, to the American Industrial Deputation, on its visit to this city, presents this small token of the mineral produce and industry of the State: it contains, besides, specimens of Mexican poetry; with the request that it be placed by its distinguished president, Mr. John Theo. Fisk, in some public institution of the United States for the inspection of its citizens and artisans."

The Institution has also received, through the honorable Secretary of State (by official letter of the department dated December 3, 1880), from the international exhibition commission of Sydney (N. S. W.), Australia (under cover of a letter dated November 8, 1880, from R. W. Cameron, esq., one of the United States commissioners to said exhibition), a specimen bronze medal of award of the said Sydney international exhibition of 1879. This medal, three inches in diameter and a quarter of an inch thick at its outer rim, presents a very fine specimen of die-sinking. On its obverse side, within a border bearing the legend of the exhibition, is represented in bold relief a female figure, standing, surrounded by emblems of the arts, supporting with her left hand a shield bearing the arms of the province, and extending with her right hand the victor's laurel wreath, while in the rear is shown in low relief the exhibition building. On its reverse side an elaborate floral wreath comprising native products forms the embellishment.

By the transfer to the Library of Congress of the greater portion of the books belonging to the Smithsonian Institution, effected shortly after the disastrous fire of 1865, the former library room was rendered available for other uses. This occupation for other more pressing requirements and purposes, necessarily prevented its further employment as a reading room. In view of the increasing number of employés connected with either the Smithsonian Institution, the National Museum, or the United States Fish Commission and Fishery Census Division, it was thought proper to make some provision by which some of the more interesting domestic and foreign periodicals received might be rendered easily accessible to them. Accordingly the corridor of the east range of the building has been fitted up as a reading room by the erection of reading desks on which are placed the successive numbers of certain serials as they come to hand. These, of course, comprise but a very small portion of the journals received by the Institution; a full list of which is given in the appendix.

RESEARCHES.

An arrangement was made by the Institution a number of years ago for the compilation of a series of tables of ascertained *altitudes* in the United States, to be collected from data derived from State and county surveys, and from miscellaneous surveys made in the construction of railroads, wagon roads, &c.; the ultimate object being the preparation of a topographic relief model of the country. This work was put in charge of Mr. Walter L. Nicholson, and a considerable amount of work was accomplished towards the end in view. Mr. Nicholson having, however, been appointed topographer of the Post-Office Department, the constant occupation of his time in the duties of his position interfered with the prosecution of this work, so that he was unable to complete his report, and for some years nothing further has been accomplished. The United States Coast and Geodetic Survey having had committed to it by act of Congress the charge of conducting a system of triangulations to connect the Atlantic and Pacific coasts, has requested the use of this material collected by the Institution with reference to elevations; but its transfer to that establishment has not yet been determined on.

A subject which has of late years attracted considerable attention from physiologists and others is the peculiar affection of vision known as *color-blindness.** This defect of chromatic sensibility exists in various degrees, and to a much larger extent than is generally supposed; and as it does not appear to be usually accompanied with other optical imperfection of the eyes, many of its subjects are even unconscious of their deficiency in this respect. Inasmuch as danger signals used at sea, upon coasts, on railroads, at draw-bridges, and elsewhere, are usually characterized by special colors, it obviously becomes a matter of the greatest moment to public safety that those immediately in charge of such signals, or appointed to observe them, should be known to be entirely free from any imperfection or disqualification in this direction. The subject has accordingly with justice assumed a character of great practical importance. In the Smithsonian Report for 1877 the Institution published the translation of a paper by Prof. F. Holmgren, of Stockholm, in which the vital consequence of this subject in many of the vocations of life, and especially those connected with traveling and communication by sea and by land, were strongly pointed out; and to this memoir is undoubtedly due in large degree the present appreciation of the subject.

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* This abnormal condition of sight is by many French writers characterized (not very appropriately) as "Daltonism."

An edition of this work had been contemplated by Prof. B. Jay Jeffries, of Boston, who has himself conducted a very extended series of independent researches in the same direction.*

LABORATORY WORK.

A large part of the time of the chemist of the Institution is occupied in determining the character of minerals sent to the Institution, with the request for information. Under a rule of the Institution, of which a copy is herewith submitted, the examination of minerals for private parties and private interests is confined to a simple qualitative examination, or, in other words, an indication of the more important elements contained therein. It is a comparatively easy matter to ascertain whether a certain specimen contains gold, silver, lead, or other metal, and examinations of this kind are made daily. In all cases, however, where an actual chemical analysis or assay is required, it is only done at the request or in behalf of some branch of the government, or for some other public purpose; in all other cases the applicant is referred to professional chemists for the investigation. It will, of course, be readily understood that if the Institution once establishes the precedent of making such assays and analyses, it would soon require the services of dozens of chemists, thus involving expense for which no adequate provision could be made, and interfering with the business of those who depend upon such work for a subsistence.

In the report of the chemist, which is submitted in the Appendix, will be found a statement of the general character of the chemical work conducted during the year, among which have been quite a number of investigations made for the government. Perhaps the most important of these was the inquiry into the so-called Tichenor process of reducing ores of gold by the use of one of the chlorides of gold. This investigation was made at the special request of the Commissioner of Patents, and conducted at the expense of the Patent Office, and an elaborate report transmitted to that officer. Very much public interest centered around the analysis, as the disposition of a large amount of money in the way of investment depended upon the decision.

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* The following memoirs on this interesting topic have been published by Professor Jeffries: 1. "Dangers from Color-Blindness in Railroad Employés and Pilots," January, 1878, Boston. (From the Ninth Annual Report of the State Board of Health.) 2. "Incurability of Congenital Color-Blindness," a memoir read at a meeting of the Suffolk District Medical Society, February 23, 1878. (Printed in the Boston Medical and Surgical Journal March 28, 1878.) 3. "Color-Blindness." A lecture on color-blindness and its practical relations. (Delivered April 11, 1878, before the Society of Arts, at the Institute of Technology, Boston.) 4. Paper "On Color-Blindness and its Dangers on the Sea." (Read before the United States Naval Institute at Annapolis, Md., March 3, 1880.)

In addition to the chemical work actually performed in behalf of the government, the Institution is not unfrequently asked (especially by the Treasury Department) to nominate chemical experts for special inquiries, a request always promptly complied with.

In view of the large amount and variety of analytical investigations continually required by the government for the faithful and intelligent administration of several of its bureaus or departments, it is much to be desired that a first-class laboratory, under efficient direction, be established in official connection with some branch of the government, where all chemical work of a public character or value can be thoroughly executed. Questions of grave importance, and subjects requiring elaborate and conscientious research, are constantly being presented in the revenue and other branches of the public service, which demand precise and authoritative determination for the satisfactory guidance of official agents, and which should be placed under the immediate supervision of those (of whatever government bureau) charged with the responsibility and interested in the accurate execution of the work.

EXPLORATIONS.

In the summer of 1879, Mr. F. H. Cushing, the assistant in charge of the ethnological department of the museum, was granted leave of absence by the Institution for the purpose of accompanying a commission detailed to carry on ethnological research and exploration among the Pueblo people of New Mexico. This expedition, in charge of Mr. James Stevenson, was very successful in its mission; collecting large numbers of specimens, an account of which was duly given in the Report of 1879. Mr. Cushing found the field of inquiry among the Indians so rich and extensive that he obtained permission to remain a longer time, and is still there. He has established himself with the Zuñi Pueblo, under the special protection of the chiefs, and has gained the confidence of the people to such a degree as to be permitted to attend all their ceremonial observances, and make notes and even drawings. An investigation into the traditions and history of the people, their manners and customs, their songs and dances, and their relationship to other tribes, has kept Mr. Cushing constantly occupied. A rich harvest of interesting discovery will undoubtedly result from his residence among these people.

Mr. Cushing has also been enabled to obtain many interesting specimens of the handiwork of the Indians, both ancient and modern, and has visited some of the mines from which minerals valued by them as precious stones were obtained. In addition to the general inquiry into the history of the Indians, Mr. Cushing has been instructed to take the census of the Zuñi village, at the request of Major Powell.

Dr. F. M. Endlich, the mineralogist of the Institution, received, in January last, leave of absence, for the purpose of visiting, as an agent of the Treasury Department, certain sugar-producing islands of the West Indies and Demerara, with a view of investigating the mode of preparation of sugars, intended especially for exportation to the United States. During his stay in the West Indies, as also in South America, he made some interesting collections for the National Museum, among them specimens of curious aboriginal pottery.

Dr. Endlich returned to Washington, after an absence of several months, but was occupied for some months in completing his report; receiving then an appointment in charge of certain mining operations in Arizona, he resigned his position in the National Museum. The work of the department of which Dr. Endlich had charge was then placed in the hands of Dr. F. W. Taylor of Washington, as will be seen by his report, given elsewhere.

The services to natural science, of Capt. Charles Bendire, of the First Cavalry, have been appreciated for many years past by scientific men, this officer, whose military record is understood to be entirely satisfactory, devoting his leisure time to collecting specimens in all branches of natural history and making very full notes in regard to the manners, habits, and peculiarities of various Indian tribes. His successive assignments to military duty have taken him into the most inaccessible and least-known portions of the American Continent, including portions of Arizona, California, Oregon, &c., which have been thoroughly explored by him. Several questions having arisen during the year in reference to the character of certain species of salmonidæ in Oregon and Washington Territory, the acquisition of specimens of which was considered very desirable in the interest of fish culture and the fisheries, Captain Bendire expressed his willingness to undertake a journey to the localities involved, provided the necessary authority and orders could be obtained from the War Department. Application to General Sherman and to the Secretary of War resulted in the completion of the necessary arrangements, by which Captain Bendire was instructed to prosecute some desired reconnoissances and inquiries, in which he would have the necessary opportunities for natural history research. Under this arrangement he left Fort Walla Walla with a portion of his command, and after an interval of several months spent in the field, returned with rich results, consisting of very complete collections of the fishes of the rivers and lakes of the interior of the country, and with other objects of natural history, which have been received at the Institution and will shortly be made the subject of special investigation on the part of its specialists.

Mr. F. A. Ober, whose important researches into the natural history and ethnology of numerous islands in the West Indies have been referred to in previous reports, made an expedition to that group of islands during the past summer, in connection with certain business enterprises. As before, he devoted such of his time as he could spare to scientific inquiry, and secured an excellent series of birds from several of the islands not previously visited. These have been duly received and entered in the catalogue of the Museum, making its series of West Indian birds by far the most complete of any in existence. It is proposed at no distant time to prepare a catalogue of the West Indian birds in the National Museum, with appropriate notes.

Mr. Ober also secured important collections of reptiles, fishes, mammals, and objects of archæology for the National Museum.

In December, 1879, Prof. David S. Jordan, of the Indiana University, as assistant to the United States Fish Commission and special agent of the Census Department, was sent to the Pacific coast to investigate the fishes and fisheries of that region. Prof. Charles H. Gilbert, of the same institution, accompanied him as assistant. These gentlemen repaired at once to San Diego, Cal., where they began work January 1, 1880. Statistics were obtained at each of the fishing towns, and large collections of fishes were made in turn at San Diego, San Pedro, Santa Barbara, Monterey, Soquel, and San Francisco. The collection obtained in Monterey Bay was especially extensive, comprising nearly one hundred and fifty species. A stay of several weeks was made in San Francisco, after which, about May 1, Professors Jordan and Gilbert left for Astoria, Oreg.; here studies were made of the "spring runs" of salmon, which, supplemented by Professor Gilbert's subsequent studies of the "fall runs" in the various rivers, have thrown much light on this intricate subject. Later a visit was made to Puget Sound, and considerable collections were obtained at Seattle, Neah Bay, Victoria, and New Westminster. On June 15, the party returned to Astoria and soon after to San Francisco. The chief ports south of San Francisco were again visited and large collections made.

About September 1, Professor Jordan returned eastward, stopping at Lake Tahoe, Utah Lake, and Burlington, Iowa, for the purpose of studying the fisheries of these regions. Professor Gilbert returned to the Columbia and Puget Sound to investigate the fall runs of salmon. In November he left San Francisco for Mazatlan, Panama, and Aspinwall, at each of which places considerable time was spent and large collections made.

The chief results of the expedition may be here briefly summarized.

1. The collection of statistics of the various fisheries along the coast.

2. The discovery of about 50 species new to science on our Pacific coast, and of nearly as many more on the coasts of Mexico and Central America.

3. The collection in large numbers of nearly every species known on our Pacific coast, about 265 in all. About 10,000 duplicates from this collection have been already distributed to the principal museums of the world.

6. The solution of many of the problems relative to the life-history of the salmon.

In April, 1880, Dr. Tarleton H. Bean, one of the assistants in the Museum, was detailed to visit Alaska to collect fishery statistics, fishes, birds, and such other objects of interest as could be obtained Through the courtesy of Capt. Carlile P. Patterson, Superintendent of the United States Coast and Geodetic Survey, and at the suggestion of Mr. W. H. Dall, who was in command of the vessel, Dr. Bean was permitted to accompany the party of the schooner Yukon, and was allowed all possible assistance and facilities for making collections. While Mr. Dall devoted his leisure more particularly to the dredging for invertebrates and bartering for native implements and ornaments, he also contributed largely to the collection of fish and other marine vertebrates. Valuable aid was extended also by Capt. E. P. Herendeen, Mr. Marcus Baker, Mr. Wm. E. Noyes, Mr. H. W. McDonald, and Mr. Sylvanus Bailey.

Dr. Bean was absent from April to the middle of November, and during that time visited Sitka, Port Althorp, Port Mulgrave, Cook's Inlet, Kodiak, the Shumagin Islands, Belkoffsky, Unalashka, Saint Paul Island, Plover Bay (Siberia), Cape Lisburne, Icy Cape, Point Belcher, Eschscholtz Bay, Port Clarence, Big Diomede Island, and Saint Mathew Island. One hundred days were spent at sea, and seventy-eight days in the various ports named. When it is remembered that rain prevented work to some extent while in port, it will be seen that the season of actual collecting was short; yet the party succeeded in obtaining 47 packages, including 32 boxes, 10 kegs, and 3 tank-boxes of natural history specimens.

Upwards of 80 species of fish and 50 of birds were secured—some rare fishes being taken in considerable numbers with a view to their distribution to other museums. Of the fish Dr. Bean has already described 14 species as new to science—one of them representing a new genus. The chief value of the fish collection, however, lies in the fact of its including many hitherto doubtful or unknown Pallasian and Tilesian species. A full series of specimens was secured, which establishes the identity of the commercial cod and halibut of the Atlantic and Pacific Oceans. Not fewer than 14 species of fishes were collected that are common to both sides of Northern America. With the addition of this summer's results, the Museum is in possession of nearly all the known Alaskan fishes. *Eurynorhynchus pygmæus* was obtained in Plover Bay, and information of its occurrence at Point Barrow. *Larus marinus* was, for the first time, taken in Alaska. A very large series of the great Unalashkan song sparrow (*Melospiza insignis* Baird) was brought down and formed the basis of demonstrating a perfect intergradation with the *M. melodia.* *Actodromas acuminata* was again captured at Port Clarence, farther north than ever before in Alaska.

A single reptile—a toad caught by Miss Sallie Ball near Sitka—forms a part of the collection.

Mr. Dall was fortunate in procuring a perfect skin and skeleton of the banded seal (*Histriophoca equestris*) in spite of the determination of its Eskimo captors to carry off at least a piece of the nose! A very large number of skulls of Eskimo dog was gathered at Plover Bay. A few good bones of fossil mammals were brought from Eschscholtz Bay.

On the island of Unalashka many skulls and implements of prehistoric Aleuts were found in cliff burial-places. At Iliuliuk, Mr. Dall obtained a great prize in the skull of a prehistoric Aleut dog from a village-site near Ulakhta Head. Throughout the Territory large collections of implements of bone, ivory, stone, wood, copper, &c., were made, some of the Eskimo north of the Arctic Circle furnishing many really valuable articles of ivory and stone.

Dr. Bean is now preparing a detailed report upon the fishes; and this, in connection with some notes on the birds, and lists of the coleoptera, lichens, &c., will form material for a Bulletin of the Museum.

Mr. H. H. Rusby, a well-known botanist of New Jersey, has been engaged for some time in investigating the botany, natural history, and archæology of New Mexico, and it gave the Institution much pleasure to be able to obtain for him certain facilities from the War Department, to aid him in his researches. His special attention has been given to botany, and he has already addressed to the Institution a number of interesting collections in this department. In archæology his principal work has been the investigation of a cave, near Silver City, New Mexico, filled with aboriginal relics, many of which he has succeeded in securing. None of these collections have, so far, come to hand; but they will probably be received in the early part of 1881. Mr. Rusby, with the true zeal of the explorer, finding his means inadequate to the carrying out of his plans, entered into certain business relations with parties in New Mexico, by means of which he earned enough to continue his labors.

An exploring trip to the remarkable natural cave at Luray, in Virginia, was made by a party from the Institution in the month of July last. An account of this visit is given in the General Appendix to this Report.

Ever since the return of the schooner Florence from her expedition to Arctic America, Captain Howgate, of the Signal Office, has been endeavoring to secure the interest of Congress in a second expedition; and to that end he purchased in Scotland the steamer Gulnare, and had it brought to Washington and placed in a condition of thorough repair. Additional timbers were placed in the vessel and it was overhauled and placed in an effective condition.

In connection with the same enterprise Congress passed a law authorizing her acceptance, by the Navy Department, and her equipment for the purpose, should she be considered seaworthy. The Secretary of

War was also authorized to make a detail of officers and men from the Army, to accompany the expedition. The plan of operations was to send the vessel to Lady Franklin Bay, with a shore party, which was then to be landed and to be provided with houses on shore, the vessel herself returning to the United States for additional supplies. The War Department did its part, by detailing Lieutenant Doane and a number of men for the purpose in question, the general supervision being placed in charge of the Signal Office. A critical inspection of the vessel was made by the several bureaus of the Navy Department, and after a careful consideration she was declared to be not sufficiently reliable to be accepted and the Secretary of the Navy declined to take the responsibility of forwarding her on the voyage. In this emergency Captain Howgate himself provisioned the vessel and furnished the necessary commander and crew, and she started on her journey via Newfoundland. Severe storms, however, were encountered and her boilers became so injured as to require repair in Newfoundland. She experienced numerous mishaps, some of which greatly injured the vessel itself and rendered the further prosecution of the enterprise inexpedient. The vessel accordingly returned to Washington with the party, and the expedition was practically abandoned for the present. Dr. Pavy, the surgeon and naturalist of the expedition, and one other, however, remained in Greenland to carry on independent researches.

Captain Howgate, with his usual appreciation of all branches of science, invited the Institution to furnish a collector to the expedition, promising to supply the necessary quarters and subsistence. It was, however, found impossible, in the brief notice given, to secure the services of a competent person, and nothing was done beyond supplying some apparatus for deep-sea research.

PUBLICATIONS.

The activity of the Institution is more marked and its influence more extended through its publications than by any other of its agencies for the increase and diffusion of knowledge among men. However useful and important its researches, explorations and collections, these would be very limited in advantage to the public were it not for the dissemination of the new truths discovered and the facts collected through the various classes of publications carried on by the establishment. These publications are growing in number, size, frequency of issue, and value every year, and more has been done in this way in 1880 than during any previous period.

For many years past the Smithsonian Institution has been in the habit of having all its memoirs (both octavo and quarto) stereotyped, as thereby the number of copies of any memoir required for the use of the public could be conveniently regulated. The demand by the public (beyond the regular supply of everything to a definite number of institutions) being very unequal, there was danger of printing either too many or too few. This induced my predecessor, many years ago, to order that everything published by the Institution should either be electrotyped or stereotyped, and the first edition for miscellaneous distribution of 250 copies was generally printed. If more than this was required a second and a third edition of similar extent were ordered. In this way the expense of an investment in paper and printing, as well as an inconvenient and possibly dangerous accumulation of materials in the building, was avoided; and it has now become possible to keep down the stock to the minimum. The stereotype and electrotype plates have usually been kept in the basement of the building; but for the greater convenience of reference and transfer to the printer when required, they have been arranged during the year in a large fire-proof room in the upper stories of the south tower.

By far the largest proportion of electrotype plates have been stored in Philadelphia in a portion of the building of the Academy of Natural Sciences of that city, and under the charge of the printers of the Institution, the T. K. Collins establishment. The Institution is under great obligations to the Academy for permission to occupy so much of its basement and for allowing, at the same time, free access to it by the agents of the Institution.

Index to Smithsonian Publications.—In the constantly-increasing mass of serial publications the general titles of which express but indefinitely the character of their contents, the preparation of special indexes has become a matter of great importance; and within the last twenty years quite a number of such publications have been made; one of these, of the most importance, namely, the Index of Periodical Literature, by Mr. Henry Poole, has been of very great assistance to students and investigators, and a still more elaborate system of indexing has lately been carried out. An association of persons familiar with this kind of work has been formed for the purpose of continuing this series of indexes. Two propositions have been made to the Institution to prepare a full digest of all the papers it has published.

Such a bibliography has, however, been in preparation by the Institution for some time past. Mr. Boehmer, one of the assistants, has prepared a full alphabetical index to the subjects of ethnology and archæology, contained in the Contributions to Knowledge, the Miscellaneous Collections, and the Smithsonian Reports; an abstract of which, published in the Report for 1879, will give some idea of its plan. The complete work will be printed as soon as funds are available for the purpose, and it will meet an acknowledged want. Similar indexes will, in time, be furnished, relating to other branches of science.

Smithsonian Contributions to Knowledge.—During the year, Volume XXII of the quarto series of "Contributions" has been made up and published, consisting of independent memoirs previously issued by the

Institution. This volume comprises 544 pages of text, illustrated by 20 plates and 474 wood-cuts; and embraces the following subjects:

Introduction, 16 pp.—1st. Explorations of the Aboriginal Remains of Tennessee. By Joseph Jones, M. D. Published October, 1876. 4to., 181 pp. 95 wood-cuts.

2d. The Sculptures of Santa Lucia Cosumalwhuapa in Guatemala. With an account of Travels in Central America and on the Western Coast of South America. By S. Habel, M. D. Published February, 1878. 4to., 94 p. 8 plates.

3d. The Archæological Collection of the United States National Museum, in charge of the Smithsonian Institution. Washington, D. C. By Charles Rau. Published August, 1876. 4to., 118 pp. 340 wood-cuts.

4th. The Palenque Tablet in the United States National Museum. Washington, D. C. By Charles Rau. Published November, 1879. 4to., 91 pp. 2 plates and 39 wood-cuts.

5th. On the Remains of Later Pre-Historic Man obtained from Caves in the Catherina Archipelago, Alaska Territory, and especially from the Caves of the Aleutian Islands. By W. H. Dall. Published January, 1876. 4to., 44 pp. 10 plates.

Palenque Tablet.—From the interest expressed by Mexican archæologists in the history of the Palenque Tablet, and in Dr. Rau's memoir on that subject, it was presumed that this paper would be translated and published by the National Museum of Mexico, under the charge of its eminent director, Señor Don Gumesindo Mendoza, and accordingly as an act of international courtesy it was determined to offer to him electrotype copies of the plates, as also a supply of phototype prints from the tablet itself. This proposal was at once thankfully accepted by Señor Mendoza, and the preparation of the translation of the text promptly undertaken. Copies of the memoir in the Spanish version, giving the text and all the notes in full, have lately been received by the Institution.

Physiological Research.—A memoir has been published during the past year on the subject of "Fever," considered physiologically as well as pathologically. The researches set forth in this work were undertaken by Dr. H. C. Wood, jr., of Philadelphia, under the auspices of the Institution; and a notice of the character of the investigation, prepared by the author, was presented in the Report for 1878. The printing of the memoir was considerably delayed by the necessity of a critical revision of the tables and calculations, which was intrusted to Mr. C. B. Young, of this Institution, and which has received from him careful and laborious attention. He also corrected all the proof-sheets. This memoir, forming No. 357 of the Smithsonian publications, comprises 266 quarto pages, illustrated by 5 plates and 16 wood-cuts. The general conclusion arrived at, as summarized in the memoir, is that the cause of fever "is simply a state in which a depressing poison or a depressing peripheral irritation acts upon the nervous system which regulates the production and dissipation of animal heat"; and that the nature of fever is "a nutritive disturbance in which there is an elevation of the bodily temperature and also an increase of the production of heat by an increase of the chemical movements in the accumulated material of the body; this increase being sometimes sufficient, sometimes insufficient, to compensate for the loss of that heat which is derived directly from the destruction of the surplus food in the body; very little or no food being taken in severe fever."

It is the custom of the Institution to give to the author a certain number of copies of his memoirs, this varying with the extent and cost of production. The author is also invited to furnish a list of specialists particularly interested in the research covered by the memoir, whether resident at home or abroad, and to these, or as many as can conveniently be supplied, copies are sent free of cost, and the fact of this being done by the request of the author is stated.

The author is also allowed to print as many additional copies as he thinks proper, at his own expense, and to dispose of them as he pleases, either by giving them away or selling them. The more extended the distribution of a memoir, the better is the principle of the Institution carried out, viz, that of the increase and diffusion of knowledge.

Dr. Wood has availed himself of this opportunity by having 250 extra copies printed and placed on the market with the imprint of J. B. Lippincott, & Co., of Philadelphia.

Meteorology.—The relationship of the Smithsonian Institution to the subject of American meteorology is well known, especially the fact that until the establishment of the Weather Bureau of the War Department the Institution had the entire burden of maintaining a series of observing stations throughout the country and of publishing the results in a series of memoirs, which are accepted as of standard value by all meteorologists. When in 1871 its system of active work was transferred to the Signal Office of the War Department the publication of digested results was not intermitted, but continued, so as to cover the entire period of activity up to the year in question.

Among the meteorological monographs published by the Institution, that on the rainfall of the United States prepared under the direction of Mr. Charles A. Schott, of the United States Coast Survey, was one of the most important. This work, with its digested tables of rainfall and the series of rainfall maps, extending from the earliest records to the year 1866, was used for a number of years in determining the questions of general climatology and the relations of plants to altitude and locality, and to the extent and degree of reservoirs for storing water, &c.

In the interval between the completion of the first work to the transfer of the system many additional observations had been made, involving the rectification of some of the general conclusions, and it was determined to publish a continuation of the work, down to 1878, embodying at the same time a recast of the generalizations. The work was accordingly placed under the supervision of Mr. Schott, assisted by Mr. E. H. Courtenay, of the Coast Survey, and completed during the year. Arrangements were immediately made for publication, including the construction of new base charts. The printing of the charts has been completed by Mr. Julius Bien and the text is in an advanced stage of preparation, and will probably be ready in a few months.

Among the important papers still on hand which have been accepted and are awaiting publication are the continuation of Professor Caswell's meteorological observations, of Providence, and the observations made by Mr. Sherman, while on board the schooner Florence as a member of Captain Howgate's polar expedition.

The observations of Mr. Sherman present many new points in the climatology and physical condition of the arctic regions, and will be a valuable addition to the other papers of a similar character published by the Institution, as illustrating the works of Hayes, Kane, McClintock, and others. The delay in the publication of these works is due to the large amount of material on hand. It is hoped, however, that in the course of a year they may be sent to press.

Archæology.—Reference has been made in previous reports to an extremely interesting collection of West Indian antiquities, probably of Carib manufacture, presented by the late Mr. George Latimer to the National Museum. This collection embraced many new forms of much interest. The stone implements of this collection possessed many peculiarities, for the most part not illustrated at all by those of the continent of North America; and a memoir by Prof. O. T. Mason, published in the Annual Report in 1876, illustrated by suitable wood-cuts, has attracted great attention at home and abroad. Its dissemination has brought to light additional collections in the West India Islands, and arrangements have been made to obtain the use of some of these for publication.

Mr. Frederick A. Ober brought from Antigua a number of interesting objects, quite different from those of Mr. Latimer; and Mr. Guesde, of Guadaloupe, has communicated to the Institution a large number of beautifully-executed drawings of full-sized specimens in his collection, accompanied by detailed descriptions. Professor Mason has undertaken to compile a special memoir on Mr. Guesde's collection, to be illustrated by his drawings and published at an early date.

The publication by the Smithsonian Institution, many years ago, of a memoir by Mr. Lewis H. Morgan, upon the terms of relationship and consanguinity employed by various nations of the world, led to the establishment of almost a new branch of philological and ethnological investigation; or at least placed it upon a substantial footing. At the time of the publication of the memoir there were few persons prepared to follow the reasoning of the author; but under its stimulus corresponding researches have been carried on in various parts of the world and have produced very good fruit.

Among such investigations was one by Mr. L. Fison, in regard to the aborigines of Australia, and an agreement was entered into with him by which the Institution was to publish it, uniform with Mr. Morgan's memoir. The number of manuscripts in hand waiting for publication prevented Mr. Fison's article from going to press, and he finally was able to make arrangements at home for its appearance. The paper was accordingly withdrawn and transmitted to the author through Mr. Morgan.

There is now a sufficient number of the quarto memoirs completed to form another volume of the "Contributions," Volume XXIII; and this will be issued early in the year 1881. It will probably comprise:

1st. Lucernariæ and their allies. By Henry James Clark. (130 pages, and 11 plates.)

2d. On the geology of Lower Louisiana and the salt deposit on Petite Anse Island. By Eugene W. Hilgard. (34 pages, 2 plates and 4 wood-cuts.)

3d. On the Internal Structure of the Earth considered as affecting the phenomena of Precession and Nutation. By J. G. Barnard. (16 pages, and 2 wood-cuts.)

4th. A classification and synopsis of the Trochilidæ. By Daniel Giraud Elliot. (277 pages, and 127 wood-cuts.)

5th. Fever: a Study in Morbid and Normal Physiology. By H. C. Wood. (266 pages, 5 plates and 16 wood-cuts.)

Miscellaneous Collections.—Four volumes of articles, heretofore published, have been made up and added to the octavo series of the "Smithsonian Miscellaneous Collections" during the year. These form Volumes XVI, XVII, XVIII, and XIX, and are constituted as follows:

The *Sixteenth* volume contains:

1st. Land and fresh-water shells of North America. By George W. Tryon, jr. Part IV, Strepomatidæ (American Melanians), 1873, 490 pp.

2d. Catalogue of the described Diptera of North America. By C. R. Osten-Sacken (second edition.) 1878. 324 pp.

3d. The Toner lectures. Lecture VII. The nature of Reparatory Inflamation in Arteries after Ligature, Acupressure, and Torsion. By Edward O. Shakespeare, M. D., 1879, 74 pp.

4th. Circular relative to Smithsonian Scientific and Literary Exchanges, 1879, 2 pp.

5th. Circular relative to Business Arrangements of the Smithsonian Institution, 1879, 7 pp.

6th. List of described Species of Humming Birds. By Daniel Giraud Elliot, 1879, 22 pp.

7th. List of the principal Scientific and Literary Institutions in the United States. May, 1879, 6 pp.

8th. List of the publications of the Smithsonian Institution, July, 1879, 18 pp.

The *Seventeenth* volume consists of:

The Smithsonian Institution: Documents relative to its origin and history: Edited by William J. Rhees, 1879, 1027 pp.

The *Eighteenth* volume consists of:

The Smithsonian Institution, Journals of the Board of Regents, Reports of Committees, Statistics, &c. Edited by William J. Rhees, 1879, 852 pp.

The *Nineteenth* volume contains:

1st. Proceedings of the United States National Museum. Vol. I, 1878, 524 pp.

2d. Proceedings of the United States National Museum. Vol. II, 1879, 503 pp.

Memoir of James Smithson.—It has long been the intention of the Institution to publish a memoir of its founder, and from time to time efforts have been made to collect materials for this purpose. It is much to be regretted, however, that this work was not undertaken at an earlier date, while some of Smithson's contemporaries were living who could have imparted valuable information as to his peculiarities and characteristics.

Mr. Rhees, Chief Clerk of the Institution, has at last supplied the want so long felt in the history of this establishment, and has made use of every known source of information in the preparation of the work in question. By extensive correspondence and advertisements in several of the leading English periodicals some facts of interest not hitherto known were secured, and the author was thus enabled to present a more extended notice of Smithson than was at first anticipated.

The memoir under notice commences with a sketch of the ancestry of the Smithson family, gives an account of the education of James Smithson at the Oxford University, where he graduated in 1786, describes his devotion to scientific pursuits, his love of adventure in the search for knowledge, recounts his achievements as a chemist and mineralogist, enumerates his published scientific works, and gives the testimonials to his worth and ability from the president of the Royal Society and others.

An inventory of his personal effects is presented, and an account of the likenesses of Mr. Smithson known to be in existence and in the possession of the Institution.

Some attention is paid to a consideration of the motives which probably actuated Smithson in bequeathing his fortune to the United States, and a *resumé* is given of the intellectual condition of the period in which he lived, which is shown to have exhibited a remarkable spirit of scientific activity, and the formation at that time of some of the most important organizations for the advancement of science, education, and philanthropy.

The promotion of knowledge was peculiarly a characteristic of the period, and Smithson was undoubtedly impressed with this idea.

Full details of the will and a *fac simile* of it are given.

Mr. Rhees then traces the steps taken by the United States Government to secure the bequest, the various acts of Congress, the debates, resolutions, messages of Presidents, &c., in relation to the subject, and finally the reception, on the 29th of August, 1838, of £104,960 8*s*. 6*d*, which, converted into American gold, realized $508,318.46 as the Smithson foundation.

A recapitulation is next furnished of the legislation of Congress in relation to the disposition of the Smithson fund, and a brief abstract of the notable speeches made from time to time in which various plans for establishing the Smithsonian Institution were advocated. These speeches are given in full in the "Documents relative to the history of the Smithsonian Institution," published in 1879; but in the present volume the narrative is continuous and the references to the names and localities of the Senators and members of Congress more minute and explicit. In an appendix additional facts are given relative to the father of Smithson, the first Duke of Northumberland; the half brother of Smithson, Earl Percy, who commanded the British re-enforcements at the battle of Lexington, 1775; notices of some of Smithson's papers; extracts from his writings; a catalogue of his library now deposited in the Smithsonian Institution; and notices of the city of Washington found in Smithson's books.

The whole forms an octavo of 76 pages, with the following illustrations:

Portrait of Smithson. Heliotype; from an oil miniature by Johns. 1816.

Portrait of Smithson. Heliotype; from an oil painting. Cabinet size; full-length figure, sitting, in the costume of an Oxford student. 1786.

Portrait of Smithson. Profile; engraved on steel; from a medallion.

Tomb of Smithson, at Genoa, Italy. Wood-engraving; from a recent photograph.

Fac simile of Smithson's visiting card, and of his dinner invitation card.

Silhouette portrait of Henry James Hungerford, nephew of Smithson.

Fac simile of Smithson's will. Two sheets, of four quarto pages.

Portrait of Smithson's father, Sir Hugh Smithson. From an engraving belonging to James Smithson.

North view of the Smithsonian Institution building at Washington.

The *Memorial Volume* in honor of the late Professor Henry, authorized to be published by Congress, though somewhat delayed, has been completed, and is now practically ready for distribution. It forms a handsome octavo book of 528 pages, of which the main subject-matter is divided into three parts. A brief introduction of 4 pages presents the proceedings of Congress in relation to the holding of memorial services in the hall of the House of Representatives, and also in relation to the printing of the same, together with such other testimonials of respect as the Regents might deem congruous with the object of the work. Part first embraces the primary proceedings more immediately connected with the obsequies, commencing appropriately with the reproduction of the announcement of the death of Joseph Henry, by the Chancellor, Chief Justice Waite, issued on the day following that melancholy event, and addressed as a formal or official obituary notice to all the correspondents of the Institution, in our own country or abroad, followed by an account of the proceedings of the Board of Regents on the occasion of the funeral services, with the sermon of the Rev. Samuel S. Mitchell, and of the steps taken by the Regents on the day following to obtain a public commemoration. Part second comprises an account of the memorial services at the Capitol, presided over by the Vice-President, taken from the Congressional Record, and consisting of an opening prayer by President McCosh of Princeton, addresses by Senators Hamlin and Withers, Representatives Garfield and Cox, Professors Gray of Cambridge and Rogers of Boston, and by General Sherman, the reading of telegrams by Representative Clymer, and a closing prayer by the Chaplain of the Senate, Rev. Dr. Sunderland. Part third comprises proceedings by, and addresses before, various bodies with which Professor Henry had been prominently connected. The volume concludes with an appendix of 4 pages, recounting the proceedings of Congress with reference to the erection on the Smithsonian grounds of a statue of Joseph Henry. The whole is followed by a general index of 12 pages.

Digest of Atomic Weights.—Among the Miscellaneous Collections a carefully-prepared digest of "Atomic Weights," by George F. Becker, of California, has been published during the past year, constituting No. 358 of the Smithsonian series. This work, comprising 150 octavo pages, consists of a collection of all the determinations of the atomic weights of the chemical elements heretofore made. The elements are alphabetically arranged, with critical notices under each, and the authorities for varying determinations, together with precise citations to the publications or records, are fully given. The whole is accompanied with a full index of the journals and other publications, both foreign and domestic, which have been laid under contribution; and a second index gives an alphabetical list of the authors of atomic weight determinations. The work evinces a pains-taking diligence in collecting from every available source (in whatever language) the information desired; and it will prove a valuable work of reference to both the theoretical and the practical chemist.

This publication is in continuation of a line of scientific manuals on the "Constants of Nature," projected by the Institution, and may be regarded as forming Volume IV of the series thus far attempted: Volume I being tables of the *Specific Gravities* of bodies, and also of their *Boiling* and *Melting Points;* Volume II, tables of the *Specific Heats* of bodies; and Volume III, tables of *Heat Expansion* of bodies. All three volumes were compiled by Prof. F. W. Clarke of the University of Cincinnati.

The Toner Lectures.—On the 13th of April, 1872, a deed of conveyance of several pieces of property in Washington, with money and other securities amounting in value to $3,000, was made by Dr. Joseph M. Toner, of this city, to five trustees, instituting the Toner lectures, and establishing a permanent and increasing fund for their support and continuance annually.

The trustees named in the deed were the Secretary of the Smithsonian Institution (then Prof. Joseph Henry), the Surgeon-General of the United States Army (then J. K. Barnes, M. D.), the Surgeon-General of the United States Navy (then J. M. Foltz, M. D.), the president of the Medical Society of the District of Columbia (then Grafton Tyler, M. D.).

The interest of this fund was set apart to be applied for annual memoirs or essays relative to some branch of medical science, each to contain some new truth fully established by experiment or observation; no such memoir or lecture to be given to the world under the name of the "Toner Lectures" without having first been critically examined and approved by competent persons selected by the trustees.

In accordance with this trust, arrangements were made for the delivery of annual lectures on subjects relative to medical science, and the Smithsonian Institution undertook their publication in its series of Miscellaneous Collections. The following is a list of the lectures published up to 1880, and already described in previous reports: I. On the Structure of Cancerous Tumors and the Mode in which adjacent parts are invaded. By Dr. J. J. Woodward. Published November, 1873, 44 pp., 8vo. II. Dual Character of the Brain. By Dr. C. E. Brown-Sequard. Published January, 1877, 25 pp., 8vo. III. Strain and Over-Action of the Heart. By Dr. J. M. Da Costa. Published August, 1874, 32 pp., 8vo. IV. A Study of the Nature and Mechanism of Fever. By Dr. Horatio C. Wood. Published February, 1875, 48 pp., 8vo. V. On the Surgical Complications and Sequels of Continued Fevers. By Dr. William W. Keen. Published April 1877, 72 pp., 8vo. VI. On Subcutaneous Surgery: Its principles, and its recent extension in Practice. By William Adams, M. D., F. R. C. S. Published May, 1877, 15 pp., 8vo. VII. The Nature of Reparatory Inflamation in Arteries after Ligature, Acupressure, and Torsion. By Dr. Edward O. Shakespeare. Published April, 1879, 71 pp., 8vo. And lastly, during the past year: VIII. Suggestions for the Sanitary Drainage of Washington City. By George E. Waring, jr. Published June, 1880, 23 pp., 8vo.

This last lecture forms No. 349 of the Smithsonian Miscellaneous Collections, and discusses a subject of special and practical importance to the residents of this city.

The health and comfort of the Capital of the nation is a matter of so general interest that its hygienic conditions deserve careful study and consideration. Very difficult problems are presented to the sanitary engineer by the topography of the city and the river frontage on a large area of flat land. The drainage of so large and so populous a city is one of the first subjects requiring the attention of the local authorities and of Congressional action. Mr. Waring having had long experience and much distinction in investigation of such topics, was, therefore, invited by the trustees of the Toner fund to make a thorough examination of the city and District, and requested to make suggestions for the improvement of their drainage.

Mr. Waring in his lecture presents Holland as furnishing a suitable example for imitation in regard to the reclamation of low areas. In that country about 4,000 acres have been reclaimed annually, while in Washington the improvement of not more than 2,500 is required. He recommends strongly the adoption of the Dutch method of constructing defenses, embankments, and bulk-heads, leaving the inclosed ground at its present level, and to drain it by artificial power to a sufficient depth to secure the same result as to dryness that would be secured by the filling it with earth. This would substitute a dry and pleasant meadow for the present noisome mud flats, would be economical, simple, and practically equivalent to raising the whole city six or eight feet above its present level, and give it high and dry ground to the shore of a clear running stream on each side.

Next to bringing the flats about the city into a proper condition, the drying of the soil of those parts now subject to saturation is considered by the author, and for the latter purpose he recommends that the damp lands should be drained by an independent system of pipes, entirely disconnected, except at their outlets, with the sewer system.

The sewerage of the city is next considered, and the use of the same drains for the streets and for houses is condemned as very objectionable. It is urged as of prime necessity that every foot of the sewers with which habitations are connected should be at all times free from deposits of organic matter.

The best size of sewer-pipes is fully discussed, and the conclusion stated that large ones should be restricted to the removal of storm-water only, and small ones used for house drainage.

A radical and almost universal improvement of the interior drainage of houses is demanded, the defective house-drains being a far more important factor in the production of disease than defective sewers. By the official statement, the deaths in the District in 1879 from diseases which are believed to be very materially affected by bad drainage, either by soil-moisture or by filth, amounted to just about one-half of the total mortality. The author believes that five hundred persons annually die within the District of Columbia because of the defective condition of the houses in which they live.

The main features of a comprehensive scheme adequate to the improvement required are stated by Mr. Waring to be—

1. The flats and marshes to be reclaimed by embanking and pumping.
2. The discharge of the lateral streams and of storm-water sewers to be carried beyond these defenses and delivered into the main channels of the river.
3. The complete underdraining or subsoil drainage of the site of the city.
4. The separate removal of the foul drainage.
5. The abolition of privy vaults and cesspools and the complete reformation of the interior drainage of houses.

Physical Tables.—Among the earliest publications of the Institution, one now exhausted, but which has ever since been in great demand both at home and abroad, is the very full series of meteorological and physical tables prepared by Prof. Arnold Guyot. This work (No. 31 on our list), published in 1852, constitutes the principal portion of the first volume of the Smithsonian Miscellaneous Collections, and is universally recognized as a standard work of reference on the subjects to which it is devoted.

The expansion of certain branches of physical inquiry has made some supplementary tables desirable, and Professor Guyot was invited by my predecessor to prepare the material for a new series. The greater part of the work will of course be unchanged, and will be printed from the original electrotype plates. But some modification of certain tables, together with a number of new ones, has been arranged for.

Professor Guyot's laborious duties at Princeton have interfered with the speedy completion of the new edition; but the material is now nearly ready, and the additional pages will be put in type at an early day.

Bulletins of the National Museum.—In addition to the regular series of publications printed entirely at the expense of the Smithsonian fund, several series prepared under the direction of the Institution have the expense of the printing of a small edition provided for from other sources. Stereotype plates of these issues are preserved, and are afterward included in the Miscellaneous Collections. These consist especially of the Bulletins and Proceedings of the National Museum, the printing of which is authorized by the Department of the Interior, and paid for out of its fund. An edition of one thousand copies is published, of which one-half is distributed by the Department of the Interior and one-half by the Institution. As the pages are stereotyped, the cost of additional copies is slight; and for the purpose of making sure that a sufficient number of sets will be accessible forever to students in all parts of the world, it has been considered expedient to print fifteen hundred additional copies of each as a portion of the Miscellaneous Collections. In this way the distribution of the first edition can be made to special students and the minor societies that do not receive full series of Smithsonian publications.

In this manner the various numbers of the Proceedings of the National Museum (forming the volumes for 1878 and 1879) have been associated together to form the nineteenth volume of the Miscellaneous Collections as already indicated. A similar arrangement has been made in reference to the transactions of the Philosophical Society of Washington, the first three volumes of which have been printed from the stereotype plates, and will probably form Volume XX of Miscellaneous Collections, to be issued early in 1881.

The "Bulletins" of the Museum, as heretofore stated, are designed to furnish check-lists, system of classification, and descriptions of the natural history material on hand, for the purpose of illustrating the zoological and ethnological collections belonging to the U. S. National Museum, &c.

The seventeenth Bulletin of the National Museum is on the zoological position of Texas, by E. D. Cope. The author considers the subject of the influence of environment on animal life, and the relation of the nearctic and neotropical faunæ at their point of junction. Studies into the zoology of Mexico have shown that the high plateau is populated by an animal life which differs from that of the coastward plains. From investigations of the Batrachia and Reptilia, which are incapable of performing migrations, the line of demarkation between the great northern and southern realms is clearly indicated. The genera of South America advance northwards along the lower lands of Central America and Mexico to the mouth of the Rio Grande, which is about their northern boundary. On the other hand various genera of the southern regions of North America extend their range southward as far as the city of Mexico.

The great State of Texas is the field where the boundaries of the various genera is to be sought, since its fauna is of a most diversified character. The geology, topography, climate, and vegetation of this region are described, and the author then proceeds to a consideration of the distribution of its vertebrate animals in the following order: Mammalia, Aves, Reptilia, Batrachia, Pisces.

The author concludes that Texas is to be placed within the nearctic realm, for although it possesses a number of genera which are common to this realm and the neotropical, there are numerous genera which belong to the former exclusively and very few that belong to the latter alone. To display these relations lists are given side by side of genera whose geographical relations are in these three directions.

The species are shown in four geographical groups, (1) those of the extreme southwest, (2) those of the plateaus, (3) those of the low country, and (4) the east.

The discussion is a valuable contribution to science, and the paper has attracted marked attention from naturalists. It forms an octavo of 51 pages.

Bulletin No. 18 is a pamphlet of 278 pages, and is entitled "Exhibit of the fisheries and fish culture of the United States of America, made at Berlin in 1880, prepared under the direction of G. Brown Goode, deputy commissioner."

This work is a catalogue of the articles brought together by the United States Fish Commission for exhibition at the International Fishery Exhibition held in Berlin in April, May, and June, 1880. An account of this exhibition and of the display made by the United States, with the awards to exhibitors, will be found in another place in this report.

The bulletin or catalogue was used as the official list or guide to the American part of the exhibition, was republished in Berlin, translated into German, and on account of its extent, classification, detail, and accuracy, elicited much praise.

The work is arranged under six sections or heads, viz:

A. Aquatic animals and plants of North America beneficial or injurious to man.
B. Fishing-grounds of North America.
C. Means of pursuit and capture.
D. Methods of preparation.
E. Animal products and their applications.
F. Research, protection, and culture.

Under each of these sections, subdivisions are made for the purpose of systematic classification.

Proceedings of the National Museum.—As stated in the reports for 1878 and 1879, another series of publications relating to the Museum has been introduced, designed to furnish to naturalists early announcements and descriptions of specimens received, particularly when of new species, together with such other matters of zoological interest as may be furnished by correspondents, to which series the title of "Proceedings of the National Museum" has been given. Of the articles published in the *Proceedings* for the year 1880, Mr. R. Ridgway has furnished the following:

(1) *Revisions of Nomenclature of certain North American Birds.* This paper is an explanatory list of the names of North American birds which, in accordance with the recognized rules of nomenclature, have been changed or amended since the publication (in 1873) of the latest catalogue of the species—Coues's "Check List." Thirty-one specific or subspecific and twenty-five generic names are given as changed or amended since that date, from the form given in the above-named catalogue, while nineteen species given therein as geographical races or varieties are raised to full specific rank, seven others being reduced to the rank of subspecies.

(2) *A Catalogue of the Birds of North America.*—This catalogue is pre-

pared with the view to supply the wide-spread demand for a catalogue of North American birds which shall be complete up to date as regards the enumeration of species known to occur in North America, and at the same time includes a thorough though condensed digest, with references of the additions to the fauna and changes of nomenclature which have been made during the period of twenty-one years which has elapsed since the publication of the last Smithsonian catalogue, in 1859. This new catalogue, with numerous revisions and additions, is now (December, 1880) being printed for publication in pamphlet form.

(3) *Catalogue of Trochilidæ in the collection of the United States National Museum.*—This is a list of the species of humming birds contained in the National Collection, all the localities represented by the specimens being given with each species. The chief object of this list is to call attention to the *desiderata*, so that correspondents may be able to furnish species which are lacking to the collection, and thus render it more complete.

Dr. Tarleton H. Bean has furnished among other papers:

A list of European fishes in the collection of the United States National Museum.—About 350 nominal species are mentioned. As this list is intended simply to facilitate exchanges with museums in Europe, the names under which the fishes were received are retained without reference to our latest knowledge concerning the classification and specific identity of certain species.

Other articles have been supplied by Messrs. S. T. Cattie, F. M. Endlich, S. Garman, C. H. Gilbert, T. Gill, G. B. Goode, O. P. Hay, A. Heilprin, D. S. Jordan, G. N. Lawrence, W. N. Lockington, R. Rathbun, J. A. Ryder, R. Smith, J. J. Smith, J. G. Swan, A. E. Verrill, and C. A. White.

Systematic Nomenclature.—In carrying out investigations in systematic natural history a large part of the labor consists in determining the priority of names, especially those of the genera employed or proposed; and for many years each inquirer was obliged to repeat the labors of others and to waste a vast amount of his time thereby. In 1846. the late Prof. Louis Agassiz prepared a list of all names of genera that had been proposed in zoölogy, giving the dates, references to place of publication, and the group of the animal kingdom to which they belonged. No greater boon could have been extended to students than this compilation, which answered its purpose fully for a number of years. In 1873, Mr. Marschall prepared a supplement to the work of Professor Agassiz, which was also of very great moment. For many years past, however, no convenient digest has been available to cover more recent researches, as the spirit of scientific investigation is increasing in almost geometrical ratio, and the need of a new nomenclature has been apparent. Mr. S. H. Scudder, of Cambridge, Mass., has devoted a large portion of time lately to the preparation of a second supplement to Professor

Agassiz's work, to include a general index to the whole; and by this means, when published, the naturalist will be able to reduce the time and trouble of a given research enormously. Mr. Scudder offered this memoir to the Smithsonian Institution for publication, but as its own funds were required for the other memoirs previously in hand, it was accepted by the Department of the Interior, as a bulletin, and work begun upon it. Some hundreds of pages have already been printed, and it is hoped that the whole will be completed in the course of 1881.

Smithsonian Annual Report.—In consequence of the delay at the Government Printing Office, referred to in the last report, the Report for 1878 was not ready for distribution until March of the past year. Being the first issued after the death of the late Secretary of the Institution, Professor Henry, it was deemed proper to devote considerable of its space to a presentation of his life and scientific work. For this purpose, the biographical memoir prepared, at the request of the Board of Regents, by Dr. Asa Gray was appended to the Proceedings of the Board, while in the General Appendix were inserted the accounts of his researches on sound with reference to fog-signaling—his latest scientific work—reprinted from the several reports of the Light-House Board, in which they originally appeared, the whole being arranged in a connected article. With the same view, also, an article prepared by W. B. Taylor on Prof. Henry's connection with the telegraph was inserted, presenting his, as yet, imperfectly recognized contributions to the scientific basis of that invention.

The other articles in the Appendix are: Accounts of explorations in Greenland by L. Kumlien, and in the Caribbee Islands by F. A. Ober; a table of some physical constants by J. Le Conte—a contribution to the proposed collection of all the constants of Nature and Art; an account of some experiments on the effect of irritation of a sensitive nerve by B. F. Lautenbach; translations of Arago's biography of Condorcet, and of Favre's biographical notice of Agassiz; an abstract of the results of the researches on Fever, made, with the co-operation of the Institution, by Dr. H. C. Wood; and a republication of a list of the apparatus in various institutions in the United States available for scientific research. The whole forms a volume of 575 pages with 12 illustrations.

A number of ethnological articles, intended for this report, were unavoidably thrown over to the next.

The report for 1879 was presented to Congress on the 10th of March, 1880, and an edition of 15,500 copies were ordered, 2,500 for the use of the Senate, 6,000 for the use of the House of Representatives, and 7,000 for the Institution. It is again a matter of regret that the publication of this work has been so long delayed. The amount of work ordered to be done at the Public Printing Office is enormous and increases every year, while the facilities for doing it remain very much the same. As an evidence of the increase of work in this office, the Public Printer states that the number of blanks printed during the fiscal year ending June 30, 1880, exceeded those printed during the previous year by 25,000,000. The number of copies of unfinished works on December 1, 1880, ordered by Congress was 922,107. It is absolutely impossible to satisfy all the requirements of the Departments and of Congress in a reasonable time, and unfortunately the Smithsonian report is delayed much beyond the desire and intention of the Institution.

In this report an unusually large space of the Appendix is devoted to anthropology—all but four of the papers, in fact, coming under that head. This was due, in part, to the increased attention given to that branch of science within the past few years, and in part to the fact that the ethnological articles prepared for the report of 1878 were unavoidably thrown over to this.

The full list of titles comprises: A study of the savage weapons at the Centennial Exhibition, by E. H. Knight; reports of American observatories, prepared by E. S. Holden from the answers to the Smithsonian circular asking for information in regard to the equipment and operations of the observatories in the United States; translations of Pisko's lecture on the present fundamental principles of physics; of Baumhauer's account of his proposed universal meteorograph for detached observatories; and of Worsaae's statement of the measures taken for the preservation of antiquities and national monuments in Denmark; abstracts of replies to the Smithsonian archæological circular; and a statement of the anthropological investigations pursued in 1879, both prepared by Otis T. Mason; an Index to the Papers on Anthropology, published by the Smithsonian Institution from 1847 to 1878, prepared by George H. Boehmer, and the following papers on local ethnology and anthropology: The French Half-Breeds of the Northwest, by V. Havard; Prehistoric Remains in Montana, between Fort Ellis and the Yellowstone River, by P. W. Norris; the Shoshonee or Snake Indians, their religion, superstitions, and manners, by Albert G. Brackett; Ruins in White River Cañon, Pima County, Arizona, by R. T. Burr; Mounds in Winnebago County, Wisconsin, by Thomas Armstrong; Mounds near Quincy, Ill., and in Wisconsin, by William Gilbert Anderson; Notes on some of the principal mounds in the Des Moines Valley, by Samuel B. Evans; Composition of ancient pottery, found near the mouth of Chequest Creek, at Pittsburg, on the Des Moines River, by Robert N. and Charles L. Dahlberg; Prehistoric evidences in Missouri, by G. C. Broadhead; Mounds in Franklin County, Indiana, by Edgar R. Quick; Mounds and earthworks of Rush County, Indiana, by F. Jackman; Primitive manufacture of spear and arrow points along the line of the Savannah River, by Charles C. Jones, jr.; Mica beds in Alabama, by William Gesner; Mounds in Washington County, Mississippi, by James Hough; Mounds in Morehouse Parish, Louisiana, by Benjamin H. Brodnax; Wampum belts of the Six Nations, by W. M. Beauchamp; Indian relics from Schoharie, N. Y., by Frank D. Andrews; Preliminary Explorations among Indian mounds in Southern Florida, by S. T. Walker; Report on the shell-heaps of Tampa Bay, Florida, by S. T. Walker; and Mounds on Gideon's farm, near Excelsior, Hennepin County, Minnesota, by Frank H. Nutter.

The whole forms a volume of 631 pages, with 205 illustrations.

Of the documents published annually by the United States Government, those of the Agricultural Department and of the Smithsonian Institution are most in demand, as furnishing general information, much sought after by various classes of the community. There is no person of general literary or scientific taste who does not find in the Smithsonian Reports something of interest, especially in the copious store of archæological information and the statements of the present condition and progress of science. The demand for the Smithsonian Reports has been responded to by the publication of quite large editions and the occasional reprints from the authorized stereotype plates. It has been found, however, impossible of late years to meet the demands in the increasing amount of interest manifested by the growing population of the United States; and although a liberal edition is published by Congress, of which about 6,500 have been assigned to the Institution for years, copies of the Report for 1877 are entirely exhausted.

Fully realizing this fact, Senator Hamlin, a Regent of the Institution, introduced a resolution providing for the increase of the printing of the number of copies to 15,500, of which 7,000 were to be distributed to the Institution. This resolution became a law, and it is hoped that the demand for the volume for 1879 now about being delivered by the Public Printer will be met.

The series of the stereotype plates of the volumes begins with 1862, and it is proposed to make application to Congress for the printing of a small edition of the volumes extending from that year to 1878, inclusive, so that sets can be furnished to the many new public libraries which have made their appearance wlthin the last few years.

NATIONAL MUSEUM.

The reasons for asking Congress for a museum building of suitable magnitude, and the steps by which this end was accomplished, have been duly presented in the preceding reports. I am happy to announce at the present time that the edifice has been substantially completed, and that preparations are being made to occupy it. In the accompanying report of the architect of the building commission all the necessary details of the plan, cost, &c., will be found.

The magnitude of the edifice, and the complexity of the organization necessary to fully occupy it, it is expected will require a considerable time, but it is hoped that the work will be complete by the end of the year 1881, and that the establishment will thereafter be in full tide of success.

As has already been explained, the new museum is not intended simply for the exhibition of objects of natural history, the controlling idea being rather that of an ethnological exhibit, especially to include illustrations of the applications of objects belonging to the animal, vegetable, and mineral kingdoms, and the requirements or luxuries of man. To this end the collections made by the Smithsonian Institution and the United States Fish Commission, for exhibition at the Centennial Exposition of 1876, and the Berlin International Fishery Exposition of 1880, come admirably into play, and constitute the basis of the material, which, however, has been largely increased from other sources.

It is proposed to devote one-fourth of the space, about 25,000 square feet, to an illustration of the mineral resources, in the form of building stones, ores, combustibles, clays, pigments, &c.

Another fourth of the building will be taken up by illustrations of the animal industries, with representatives of the originals, or plaster or papier-mache casts, of the principal animals used for food or other purposes by man, together with all the various apparatus by which they are pursued, captured, and utilized; then the results of the manipulation, and also illustrations of the methods by which animals are protected or multiplied; this confining itself principally to an exhibition in connection with the artificial propagation of fishes and other aquatic animals.

A portion of the building will be filled by the display of other special objects, including the *materia medica*, foods, paints, and dyes of all nations.

In the purely ethnological collections, or such as relate to the savage or semi-civilized races of modern times, space will be provided for in this building, and a small area assigned to the exhibition of mounted mammals and osteological specimens. Fuller details of arrangement will be reserved for the next report.

The expansion of the scope of the National Museum of course involves an enlarged force, and the engagement of several specialists to take charge of their respective departments. This has been deferred until 1881.

In view of the large number of cases required in this building—not less than one thousand in all—the selection of suitable plans and modes of construction has been a matter of great importance, and we have accordingly endeavored to obtain all possible information as to methods of arrangement in foreign and home museums. Professor Agassiz has kindly supplied working drawings of the newer cases of the Museum of Comparative Zoology; and the authorities of South Kensington and the new British Museum, as well as those of the Royal Museum of Dresden, and other establishments, have rendered similar facilities. Mr. G. Brown Goode, the curator of the museum, during the period of his action as commissioner to the Berlin International Fishery Exposition, took occasion to visit all the principal museums in Germany, Italy, and Great Britain, and made himself familiar with the arrangements prevalent therein. The result has been to supply many important ideas, which will be carried out in connection with the new National Museum at Washington.

In the necessary reorganization of the whole force of the museum, in connection with the new departure, occasion was taken to reiterate and enforce the rule which is adopted in most public museums throughout the world, namely, that the officers connected with the museum shall make no collections of any kind whatever for themselves during the period of their connection with it. Although in most cases a mere matter of form, it has been thought well to make such a rule a condition of acceptance of a position and salary, as thereby preventing any misunderstanding and removing any danger of making an official position the means of promoting private interest. Persons in charge of a collection have many opportunities of securing specimens from visitors, who offer objects of more or less interest, and who are sometimes inclined to give them to the officer rather than to the collection.

Increase of the Museum.—The additions to the National Museum during the year 1880 have been fully up to the average, indeed scarcely inferior to those of any previous year, with the exception of that of the Centennial Exhibition at Philadelphia. The collections of marine animals, especially fishes and invertebrates from the Atlantic and Pacific coasts of the United States, far exceed in value and extent those ever before obtained. The most important sources of supply have been (1) the collections of the United States Fish Commission, made on the south coast of New England, and of the Gloucester fishermen, obtained for the most part off the eastern banks, and transmitted through the commission; (2) the collections made by Profs. D. S. Jordan and Charles H. Gilbert, of fishes and invetebrates, between San Diego and Puget Sounds; (3) the collections of Dr. T. H. Bean and Mr. William H. Dall in Alaskan waters of the North Pacific and in the Arctic Ocean; (4) collections of marine animals made by Dr. White, Surgeon of the United States revenue steamer *Corwin*, and by Captain Hooper commanding; (5) the general ethnological and zoological collections of Mr. E. H. Nelson, of the United States Signal Service; (6) collection of archæological objects made by Mr. James Stevenson, assisted by Mr. F. G. Galbraith. While, however, these are the most noteworthy there are many others of great interest that will be referred to hereafter. The catalogue of donations accompanying the report will give fuller details on this subject, bearing in mind that no small number of contributions have been received without indications of their origin, so that it becomes impossible to make the proper acknowledgments to their contributors.

The regions covered by these contributions relate almost exclusively to North America, a few collections only coming from Mexico or the

West Indies; and a still smaller number from the rest of the world. A number of very important series of fishes was obtained by Mr. Goode at the Berlin Fishery Exposition, but as they have not been unpacked and arranged, reference to them will be deferred until the next report.

Alaska, as the least known portion of North America, and the one presenting the most numerous problems of interest, received special attention during the year, and the amount of material gained has been proportionally great.

Mr. E. W. Nelson, observer of the signal office at Saint Michaels, has continued his most important transmissions covering all branches of scientific inquiry; among these the most specially noteworthy is the collection of ethnological materials, illustrating the manners and customs of the living Esquimaux of the region, as well as much of prehistoric antiquity. Mr. Nelson has already sent in about 6,000 pieces of anthropological matter. His collections of mammals, birds, &c., have been of very great importance.

Under orders from Captain Patterson, of the Coast and Geodetic Survey, Mr. Dall, assistant of the Coast Survey, made a second visit to the Alaskan seas in the schooner *Yukon*, originally built under his direction for the service. By permission of Captain Patterson, seconded by the invitation of Mr. Dall, Dr. T. H. Bean was detailed to accompany the expedition for the purpose of investigating especially the fish and fish eries of the northern waters.

The vessel left San Francisco in April, 1880, and touching at various points passed into the Arctic Ocean, where quite an extended cruise was prosecuted in the interest of the survey. It returned to San Francisco in November, 1880, and the collections of specimens, in forty-five packages, were received not long after in Washington. These embrace very large numbers of ethnological and archæological objects, specimens of birds, fishes, invertebrates, and other articles of great interest, to some of which further reference will be made.

No collections were received this year from Mr. Lucien Turner, superintendent of the volunteer stations of the Signal Service of the Aleutian Islands. Large gatherings, however, have been made by him which will be due during the year 1881.

Mr. James G. Swan, of Neah Bay, Puget Sound, has continued his valuable contributions to the National Museum, which have now extended over a period of many years. Being especially interested in ethnology, specimens belonging to that branch were particularly attended to, while many fishes also have been forwarded.

Commander L. A. Beardslee, of the *Jamestown*, stationed at Sitka, Alaska, has also made many contributions of birds and ethnological objects.

A most important and extended exploration of the Pacific coast was that conducted by Prof. D. S. Jordan, assisted by Charles H. Gilbert. Professor Jordan was detailed by Mr. Goode, in charge of the fishery branch of the census of 1880, to obtain all the procurable information in regard to fishery of the western coast; and leaving Washington in December, 1879, after spending some time in San Francisco he proceeded to San Diego and thence by successive stages to Puget Sound, his work there overlapping and uniting with that of Mr. Swan. In this work he embraced the opportunity of making extensive collections of alcoholic specimens, of which no less than 65 large cans were transmitted. These contain about 260 species of fishes, a number of them new to science, and for the most part in sufficient numbers to supply many institutions with duplicates, and to transmit desirable exchanges abroad.

The revenue steamer *Corwin*, on her usual cruise in the seas of Northern Alaska, during 1879, was accompanied by Dr. R. White, of the Marine Hospital Service, and a trained, ardent naturalist. Many important collections were made by Dr. White, especially of seals, including many fœtuses, birds, and fishes. His specimens were received in the early part of the year, and submitted for examination to various experts. I regret extremely to have to report the untimely death of Dr. White, partly from exposure in the service. In a second cruise of the *Corwin* in the North Pacific and Arctic Ocean, in 1880, Captain Hooper made another collection of great interest, including a series of fossil bones from Kotzebue Sound.

Mr. Belding, of Stockton, Cal., has furnished some interesting objects from the interior of the State. The most important contributions, however, from the inland portion of the Pacific region have been those supplied by Capt. Charles Bendire, of the First United States Cavalry, an officer the value of whose services in the development of a knowledge of the natural history of the West can scarcely be overestimated. For many years, while stationed at military posts, he has been occupied in securing eggs, nests, and birds, and other objects, and placing the information and material thus gained in the hands of correspondents and scientific specialists throughout the country. This service to science has not involved any interference with his duties as an officer, his military record being a brilliant one. Some months of the year 1880 were occupied by Captain Bendire in the investigations of certain vexed questions connected with the salmonidæ of Oregon and Washington Territory. Leaving with a small party of men he visited numerous localities and brought in a series of fishes, which, when fully examined, will enable us to solve many problems in regard to them. Many other specimens, as birds, &c., were obtained by Captain Bendire and transmitted to Washington.

Arizona has been represented by collections of living reptiles, furnished by Dr. Corson and Dr. Moran, of the United States Army, as also by a series of plants from Colonel Burr.

The contributions from New Mexico have been extremely important, consisting, first, of a series, in 1879, of specimens gathered by Mr. James Stevenson, with the assistance of Mr. Frank H. Cushing; and, secondly, of a series gathered by Mr. Stevenson in 1880, assisted by Mr. Galbraith. These explorations were under the immediate direction of Maj. J. W. Powell, in charge of the Smithsonian Bureau of Ethnology; their special object being the acquisition of a complete series of objects illustrating the manners and customs of the pueblo towns of New Mexico and Arizona. The investigation was carried from village to village, and about one-half of the articles have been thoroughly worked up. The collection embraces an immense quantity of pottery, of stone implements, dresses, ornaments, &c. Mr. Hillers, a competent photographer, accompanied both expeditions and obtained a large number of photographs, as also the measurements of various Indian towns, both occupied and abandoned, to serve as materials for a series of models.

Dr. J. C. Merrill, of the United States Army, has sent in a valuable general collection from Fort Shaw and Montana.

Mr. Charles Rusby has also sent in some rare mammals from Wyoming Territory.

The collections from Florida have been very extensive and valuable. These consist, in part, of large numbers of fishes, furnished by Mr. Silas Stearns, of Pensacola, while in the employ of the fishery branch of the United States census and subsequently; and Mr. S. T. Walker, who, in addition to fishes and reptiles, has sent large numbers of objects obtained from the Indian mounds. From Mr. James Bell, of Gainesville, have also been received valuable collection of ethnological objects and of living reptiles, including many specimens of serpents of unusual size, which have served to swell the series of plaster casts exhibited in the National Museum.

The Atlantic coast of Florida and other Southern States is well represented by collections of fishes by Mr. R. E. Earll and Prof. M. McDonald, of the fishery census department. From, or through, Mr. C. C. Leslie, an extensive and well-known fish dealer of Charleston, have also been received many rare and some undescribed species of fishes.

The operations of the United States Fish Commission have furnished a large number of objects from the middle coast of the United States, especially from the line of the Gulf Stream south of New England. Further reference to this will be made under the special head of the Operations of the United States Fish Commission. The receipts through the Commission include, also, large numbers of specimens obtained by the Gloucester fishing fleet, and which is furnished in an alphabetical record of the donors.

The ornithology of the peninsula of Virginia in the vicinity of Cobb's Island has been well investigated by Mr. Robert Ridgway, Mr. Henry Marshall, and Mr. P. Jouy, all connected with the National Museum. Many interesting birds, with their eggs, and of the young in downy plumage, were secured in good condition for mounting.

On the western coast of Mexico, and especially in the Gulf of California, Mr. Charles H. Gilbert, after completing his census work on the

California coast, made large collections of fishes for the National Museum. Not much else has been received from Mexico beyond some contributions from its National Museum, through the director, Mr. G. Mendosa, and some interesting objects from Prof. A. Dugès, of Guanaxuato.

Previous reports have contained an account of the important services of Mr. F. A. Ober in his natural history explorations in the West Indies. This gentleman has renewed his work in that region in visiting a number of islands previously unexplored by him, and in sending the material results to the Institution. The National Museum now, by his assistance, contains by far the most complete collections of the birds of the West Indies in existence.

Dr. H. H. Nicholls, of Dominica, W. I., has also made some valuable contributions, including a large and undescribed species of parrot, named by Mr. Lawrence *Chrysotis nichollsii.* The collections from Dr. Nicholls include, also, some very interesting fishes, &c. From Mr. L. Guesde has been received a series of excellently painted illustrations of Carib antiquities in his possession, or accessible to him on the island. These it is proposed to reproduce in a memoir to be published by the Institution.

Mr. Edward Newton, colonial secretary of Jamaica, has favored the Institution with several specimens of living boas, to be reproduced in plaster. Professor Poey, the eminent naturalist of Havana, has also sent living reptiles, together with a number of fishes,—types of his elaborate papers.

South America is mainly represented by the contributions of Mr. Figyelmesy, United States consul at Demarara. This collection consists of ethnological objects, including a large boat, such as is used by the natives.

As already stated, the collections from Europe have been principally series of fishes obtained for the most part by Mr. Goode at the Fishery Exposition in Berlin, and furnished in exchange for series of fishes, &c., carried from Washington for the purpose.

Some desirable specimens of native handiwork from Western Africa have been forwarded by Mr. Smythe, the United States minister at Liberia.

Having thus given a brief sketch of the principal regions illustrated by the collections transmitted during the year 1880 to the National Museum, a reference to the objects themselves in their systematic order may not be amiss.

Mention has already been made of a large number of general collections from different localities; that is to say, transmissions embracing more than one particular group of objects. The most important of these were received from Alaska, Florida, and New Mexico, although many of more or less importance came from other regions. In later years the collections most attractive to visitors in a public museum have been those illustrating the character and mode of life of the various portions of the human race, more especially of those whose existence on the globe dates back to a greater or less period in the remote past; and it is in this direction that the National Museum may claim a special importance so far as North America is concerned. With the exception of fishes, the larger number of objects received relate to archæology and ethnology. A prominent collection of this character is that transmitted by Mr. E. W. Nelson from Saint Michaels. This embraces illustrations of the handiwork of the Esquimaux of a large portion of Northwestern Alaska, gathered in the journeys made by Mr. Nelson under great risks and privations. They include objects of special interest in the way of modern carvings of bone and stone, as well as many purely prehistoric articles obtained from old Esquimaux settlements, long since abandoned. Mr. Nelson's return is expected in a year or two, and he will then devote himself especially to the preparation of a series of elaborate reports on these and other researches.

Scarcely inferior in interest and value are the ethnological collections made by Dr. T. H. Bean and Mr. William H. Dall, on the voyage of the United States schooner *Yukon*, to which reference has been made in previous pages. These were gathered at points of the cruise of the vessel on her journey from Sitka and various landing places of the North Pacific and the Arctic Oceans.

Captain Beardslee, of the Navy, has also furnished some valuable additions to the Alaskan series.

The collections made, under the direction of Maj. J. W. Powell, by Mr. James Stevenson, with the assistance, first, of Mr. Frank H. Cushing, and, second, by Mr. Galbraith, constitute enormous additions of material to the National Museum, illustrating the character of the pueblo tribes of New Mexico. They embrace many thousands of specimens of pottery, dresses, ornaments, weapons, &c.

For further information in regard to the smaller collections in anthropology, reference may be made to the alphabetical index of donors. Of special note, however, among these, are some objects of stone collected by Judge Henderson from the Naples mound in Illinois.

From Don Ignacio Galendo, of Monterey, was received an ancient mummy from a cave in Coahuila. A stone image from Mr. Latimer, of Porto Rico, constitutes an important addition to the collection of Porto Rican antiquities bequeathed to the Smithsonian some years ago by Mr. George Latimer, his uncle.

Mr. Figyelmesy, of Demarara, has sent some interesting objects, consisting of an Indian boat, some Indian pottery, &c.

Of *mammals*, the most important contribution is that of a large series of fossil bones (including some reptiles) from Capt. E. Crawford, U. S. A. These, at his request, have been placed at the command of Professor Marsh for investigation.

A fine skull of the fossil beaver (*Castoroides*) was obtained by exchange from Professor Kost, of Adrian College.

An extremely important addition to the collection of North American mammals is that of two good, mountable skins of the *Histriophoca equestris*, or parti-colored seal of the North Pacific, of which only a tanned skin had been previously in possession of the Museum. These were obtained through the instrumentality of Mr. Dall.

Dr. White, of the Revenue Marine, obtained many specimens of fur seals, including several embryos in alcohol. The Alaska Commercial Company also supplied a similar collection. Judge Caton, of Illinois, so well known for his great work on the ruminating animals of North America, has furnished a specimen of *Hydropotes inermis*, a small hornless deer belonging to China.

Captain Howgate has presented two full-blooded Esquimaux dogs, which have been sent to the Zoological Garden in Philadelphia for safe keeping. From the garden itself has been obtained a series of skeletons of monkeys that had died in the garden. An embryo porpoise from Mr. E. E. Small, of Provincetown, is also highly valued.

Of *birds*, many collections have been received, the most important being the Alaskan series from Mr. Nelson, Dr. Bean, and Captain Beardslee. Captain Bendire has furnished some much-appreciated skins from Washington Territory; and a series of the birds of California, from Mr. L. Belding, of Stockton, has filled some important gaps in the collections.

During the summer Mr. Ridgway, curator of ornithology in the Institution, accompanied by Mr. Henry Marshall, taxidermist, and followed subsequently by Mr. P. Jouy, an assistant in the Museum, visited Cobb's Island on the peninsula of Eastern Virginia, and obtained a series of adults and young of a number of water birds from the remarkable breeding grounds of that island.

A few specimens of Barrow's Golden eyed duck, in the flesh, were furnished by Mr. G. A. Boardman.

The barnacle goose (*Bernicla leucopsis*), presented by Mr. J. J. Kendall, of New York, is the first specimen of that species obtained by the Museum from a locality within the limits of the United States, although a skin was received several years ago from Hudson's Bay.

A finely-mounted specimen of the trumpeter swan, killed in Wisconsin, was furnished by Prof. T. Kumlien, and a mounted sand hill crane by Mr. Prouty.

The accessions of birds from Mexico and Central America were fewer than usual, although some interesting Mexican specimens were furnished by Professor Dugès.

An important addition to the West Indian collections was made by Dr. Nicholls, of Dominica, in the form of a new and large species of parrot. This, as previously stated, has been described by Mr. Lawrence as *Chrysotis nichollsii*. Mr. Ober, in a renewed visit to the West Indies, also added considerably to his former gatherings from islands previously unvisited by him. The first series of his collections was obtained by the Institution and placed in the National Museum.

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The additions of *reptiles*, although not very extensive, have been very important, especially in the way of living specimens to serve as models for a series of plaster casts. Among these were living Gila monsters (*Heloderma suspectum*), from Dr. Corson and Dr. Moran, of the United States Army, together with some turtles and lizards.

A living leather back turtle was sent from York River, Chesapeake Bay, by Mr. J. Henderson. Mr. Bell, of Gainesville, Fla., transmitted a magnificent series of most of the serpents of that State; among them a banded rattlesnake, nearly seven feet in length. These have been for the most part cast in plaster. Some of them were supplied to Dr. Mason, of Newport, for examination and to serve as material for microscopical investigations of the tissue of the brain and spinal marrow.

Living boas were furnished by Mr. Edward Newton, of Jamaica, and Professor Poey, of Havana, the latter gentleman sending also some living species of lizards and snakes.

Fishes.—As might be imagined from the activity manifested during the year by the United States Fish Commission, and the fish census of 1880, the collection of *fishes* has received great additions, no previous year in the history of the National Museum comparing with it in this respect. The most important contributions in this department consisted of the collections by Prof. D. S. Jordan and Mr. Charles H. Gilbert, of the fishery census. These gentlemen devoted a number of months during the year to the systematic investigation of the food-fishes of the western coast of the United States, and traversed the whole region from San Diego to Puget Sound in their researches. The results filled 65 large tin cans, of 4 to 6 cubic feet each. About 260 species in all were obtained, many of them new to science. Seventy duplicate sets of specimens were secured for distribution to the principal museums, at home and abroad, and will be promptly transmitted to their respective destinations.

Mr. Gilbert, after completing his work on the California coast, started on his homeward journey by way of the Isthmus of Panama, and has already made very large collections in the Gulf of California.

Mr. James G. Swan, of Neah Bay, Puget Sound, also obtained and transmitted many specimens of fishes of that locality. The American waters farther to the north were thoroughly explored in the interest of ichthyology by Dr. T. H. Bean. The results amounted to between 80 and 100 species, some of them new to science, and others, long lost species, of Pallas, &c.

Captain Hooper, of the revenue cutter *Corwin*, also transmitted some valuable collections from the Arctic Ocean, among them a species of *Coregonus* from Point Barrow.

Commander Beardslee, of the sloop of war *Jamestown* stationed at Sitka, secured a number of desirable species. One of the most interesting collections of the year was that made by Captain Bendire in the interior waters of Washington Territory, in the course of a journey instituted by him, with the permission of the War Department, for the purpose of solving certain problems connected with the fishes of the Columbia River and other waters, and especially the red fish of the Wallowa Lake. His collections are now in the Museum, and will be duly reported upon at the proper time.

A number of collections of fresh-water fishes from the interior of the continent, especially from Utah, were furnished by Mr. G. K. Gilbert, &c. A collection of Mississippi Valley fishes, from Prof. Q. P. Hay, is also highly prized.

The fishes of the Gulf of Mexico were furnished in large numbers during the year by Mr. Silas Stearns, of Pensacola, and Mr. S. T. Walker, many of them undescribed species.

The South Atlantic coast is represented by some very valuable specimens obtained by Mr. C. C. Leslie, a fish-dealer of Charleston, who has previously placed the Institution under many similar obligations. He was also instrumental in securing a number of collections made from the outer islands or banks of the southern coast.

Mr. R. E. Earll and Col. M. McDonald, of the fishery census, have also made and transmitted many extremely interesting collections, all tending very greatly to complete the east coast species.

The first specimens of the eagle ray, sometimes called the devil fish, obtained by the Institution were furnished by Lieutenant Sweitzer, U. S. A. This species sometimes obtains an enormous magnitude, reaching 20 or even 25 feet across the fins.

As a regular contributor, Mr. E. G. Blackford, of Fulton Market, New York, has continued to furnish some very desirable species, his vigilance being constantly exercised to obtain whatever he thinks is new, and to forward it to the Institution.

The collections made by the United States Fish Commission, in its coast explorations during the year, have been of unusual value, no less than 20 undescribed species of deep-sea fish having been taken during the summer, with others not previously obtained, but already known.

As usual a large number of rare, and some new, species were obtained from the members of the Gloucester fishing fleet, through the instrumentality of Mr. A. Howard Clark, of the Fish Commission, stationed at Gloucester. The most noteworthy additions to the Museum resulted from the work by the *Fish Hawk*, on the edge of the Gulf Stream, where four day's work furnished 20 new fishes and over 150 species of mollusks, of which about 40 were new to science. Other invertebrates of interest were supplied by the Gloucester fishermen, and a number of desirable species were obtained by Professor Jordan, Mr. Swan, Captain Beardslee, and Messrs. Bean and Dall from the Pacific coast.

Among interesting illustrations of the progress and results of the fish-cultural operations of the country received during the year have been several species of salmonidæ, sent in by Mr. Stone from the McCloud River. Mr. N. K. Fairbanks has furnished a specimen of California salmon, caught in Geneva Lake during the summer, weighing about 10 pounds, this being undoubtedly one of the young fish introduced into that lake some years before, hatched from eggs supplied by the United States Fish Commission from the McCloud River establishment.

Another important specimen was that of a carp, from Mr. G. B. Mobley, of Texas. This fish was one of a sending into Texas by the United States Fish Commission in April, 1880, at which time it was about 4 inches long and probably weighed but little over an ounce. Eight months after it was brought back from Texas to Washington, measuring 21 inches and weighing more than four pounds! a very remarkable illustration of the rapidity of the growth of this fish in America.

The acquisition, through the instrumentality of Mr. E. W. Dennison, of Boston, of a large brook trout was also a subject of interest, this fish weighing more than 11 pounds and being one of the largest of the kind ever taken within the limits of the United States.

Of exotic fishes the most important are several series of European species, obtained by Mr. Goode at Berlin and from his colleagues at the International Fishery Exhibition.

Reference to these will be found on another page.

A collection of fishes made some years since at Beyrout, in Syria, by Dr. Kidder, of the Navy, was received last year, in good condition. Professor Poey has continued his contributions of type species from the Cuban waters.

A valuable miscellaneous series of fishes was supplied by the Museum of Comparative Zoology of Cambridge, embracing species from both North and South America.

Mr. Vinal Edwards, of Wood's Holl, an agent of the United States Fish Commission, has also continued his services in the constant watch for rare stragglers.

In the preparation of the exhibit by the United States at the International Fishery Exhibit at Berlin in 1880, invitations were sent to many firms for contributions of specimens. These were quite readily complied with. Purchases were made from other parties who declined to contribute, and who consequently lost the opportunity of competition. A special catalogue will be furnished of this series. The collections, for the most part, have been brought back to Washington, to form part of the exhibit of fishery products in the new National Museum.

Shells.—One of the most important additions to the collections of the National Museum during the year has resulted from the presentation by Mr. W. G. Binney of his entire collection of American Land Shells. The history of this division of the mollusca, so far as North America is concerned, is closely connected with the name, Mr. Amos Binney, father of William G. Binney, having devoted especial attention to the air-breathing land shells, and published a very elaborate and costly work on the subject. The son took up the same group with the material left by Dr. Binney, and has devoted many years of an active and laborious scientific career to it. In the collection received from Mr. William G. Binney are to be found the types of both these series of researches, furnishing a collection scarcely equalled, certainly not surpassed, by that of any other museum in the country.

The possession by a public museum of such a type collection as Mr. Binney's is always considered a matter of very great importance, especially as the objects are thereby more assured of continued preservation and ready accessibility to students. It is to be hoped that additional donations of the same character may be made from time to time, as no better depository can be found in any other establishment.

Plants.—As the Department of Agriculture has the special charge of the investigations relating to the vegetable kingdom, and is supposed to take the necessary steps towards securing representations in its herbarium, no special effort is made by the Smithsonian Institution to invite or secure contributions, although whatever is received is immediately transferred to that establishment. The only accession of importance during the year is that of a series of plants of Japan, contributed by the Mombusho or educational department of Tokio.

Fossils.—Of fossil remains large collections of invertebrates have been deposited by Capt. Geo. M. Wheeler, and others have been presented by Mr. B. H. Lyon and other paleontologists.

Minerals.—Many valuable mineral collections have been received from various sources, for the most part illustrating economical geology rather than geology proper. The largest collection has been that of eight boxes collected by Mr. Thomas Donaldson. Mr. Anthony Pirz has furnished two magnificent stalactites from the Adelsberg cave in Carniola.

Paintings.—Among the collections which will form part of the objects in the National Museum, a very interesting and instructive exhibit will consist of the Indian portraits and scenes painted by the late George Catlin. These pictures, all from living subjects and of great merit as faithful portraitures of aboriginal life and manners, were presented to the Institution in 1879, by Mrs. Harrison, of Philadelphia, but the paintings have necessarily been stored since their receipt, awaiting the completion of the new Museum. They had also been stored in ware-rooms in Philadelphia for many years, so that to preserve and present them in a suitable manner with frames, &c., will require considerable expenditure.

Miscellanea.—The institution is under many obligations to General Meigs for the presentation of medallion likenesses in plaster, of the size of life, of George Washington, Abraham Lincoln, W. F. Seward, and Salmon P. Chase, which were prepared for use in the extension of the U. S. Capitol building. As works of art, as well as likenesses of eminent citizens, they are regarded as of much value and will be carefully preserved in the historical and art department of the National Museum.

Work done in the Museum.—As in previous years, the time of the several curators of the Museum and of their assistants has been, to a great degree, occupied in receiving the collections coming from various sources, doing to them what is necessary for their permanent preservation, entering them in the record-books, properly labelling them, and then placing them in their appropriate receptacles.

The magnitude of this labor may be easily understood from what has been said of the increase of the Museum during the year, no single establishment in the United States, nor, perhaps, in the world, being in receipt of so great a number of objects requiring such treatment. In most establishments where a large amount of material is received from time to time, this comes, for the most part, by purchase or donation, the several collections having already passed under the hands of the taxidermist or specialist, so that all that remains is to properly place the matter in a position for permanent preservation. The aggressive campaign, carried on directly or indirectly by the Smithsonian Institution in unoccupied fields of research, involves a greater amount of labor in treating the spoils of conquest. A statement of the general circumstances attendant upon the transmission of a miscellaneous collection of specimens may perhaps serve as an illustration of what is here stated. Thus, an explorer in the field announces that he has transmitted a certain collection from a given locality to the Institution. An entry is made of the fact in what is called the announcement book, which is ruled in columns to show successively the date of announcement, the name of the sender, his address, the point from which the sending is made, the general nature of the transmission, the agent to or through whom forwarded, and the mode of conveyance. There are then left two blank columns, one indicating the date of the arrival, the other the freight and other charges, which are filled up at the proper time. When the package arrives the date is entered in the announcement book, and an entry made in another volume (the transportation record). The collection or object is then recorded in still another volume (accessions to the Museum), and has affixed to it a "donation" number. Should there be any letter or memorandum accompanying the parcel or consignment, with fuller details than simply the locality and sender, it is transmitted with the package to the general curator, under whose direction the latter is opened and the contents assorted. Mammals, birds, reptiles, &c., are assigned respectively to the various curators, whose business it is, if possible without delay of a single day, to enter the specimens in the respective Museum registers, and to affix a number, as ineffaceable as possible, corresponding to the entry in what is called the Museum Register.

At this stage it is not necessary that the specimen be accurately identified and named, as it is supposed that this can at any time be done by the specialist. Care, however, is exercised to make an entry of the donor, locality, date, and other facts of the history of the object that a simple inspection or study will not furnish. After this the various articles are placed where they properly belong. Some, however, require further treatment by the taxidermist or otherwise.

Should the specimens belong to the ethnological series, and be composed of animal substances, as of woolen material, fur, &c., they are carefully treated with a solution of corrosive sublimate in alcohol, so as to prevent danger from insects, and finally placed in the cases where they belong, or packed away until they can be properly considered. Of course, collections well dried, shells, minerals, fossils, &c., require little treatment preliminary to their final disposition.

This Museum work, as already stated, occupies the greater part of the time of the assistants, although most of them find the occasion and the leisure to prepare critical monographs in regard to certain species, which are then, for the most part, published in the Proceedings of the National Museum.

The total number of entries in the record books of the Museum during the year, as shown by the detailed list appended, embraces 14,586 numbers, averaging probably four or five distinct objects to each entry. Where a number of articles of the same general character, from the same locality, are received from the same donor at the same time, the same number may be affixed to all of them, as in the case of a collection of shells, of fossils, of stone implements, &c. The total number of entries and dates amounts to over a quarter of a million (actually, 281,511), and fill over 60 large folio ledgers.

Among the more special investigations conducted by the naturalists of the Institution, upon which papers have been prepared, are those on archæology, by Dr. Charles Rau; on fishes, by Mr. G. B. Goode, and Dr. T. H. Bean; on the birds, by Mr. Robert Ridgway; on the fossils, by Dr. C. A. White. Dr. F. M. Endlich, before leaving for the West Indies, and subsequently Dr. F. W. Taylor, made numerous examinations as well as analyses of minerals.

Among investigations by collaborators not directly connected with the Institution have been, those of crustacea, by Profs. S. J. Smith, Oscar Harger, and E. B. Wilson, of Yale College; of mollusks, by Professor Verrill and Mr. Sanderson Smith, of New York; of radiates and worms, by Professor Verrill; of reptiles, by Prof. E, D. Cope, of Philadelphia; of fishes, by Mr. S. E. Garman, of Cambridge; of birds, by Mr. George N. Lawrence, of New York, Dr. Elliot Coues, and Mr. Henshaw; of mammals, by J. A. Allen, of Cambridge, and Dr. Coues.

The more important investigation in the marine invertebrates, however, has been made directly by Prof. A. E. Verrill, of Yale College, or under his supervision. The insects have been transmitted to Prof. C. V. Riley and Professor Comstock, of the Department of Agriculture; the plants have been referred to the Department of Agriculture or to Prof. Asa Gray, of Cambridge.

Work done on collections.—For a number of years past the Smithsonian

Institution has been in receipt of soundings taken by vessels of the United States Navy in various parts of the world, and they have been held in the hope of being able to make some definite arrangement for disposing of them. As, however, there were no funds of the Smithsonian Institution or of the Navy for meeting the cost of investigating them and publishing the results, with the necessary illustrations, nothing was done beyond placing them in charge of Prof. Hamilton L. Smith, of Geneva, N. Y., one of our best-known microscopists, and particularly interested in the class of objects referred to.

During the explorations of the *Challenger* particular attention was paid to the collecting of samples of the sea bottom, and on her return to England this branch of research was placed in charge of Mr. J. Murray, and at the request of this gentleman, indorsed by Professor Smith, the material in hand was sent to him to be elaborated in the preparation of the systematic work covering the entire field. This was with the stipulation that a special report should be prepared upon the material collected by the vessels of the Navy, to be published, if so desired, by the Navy Department.

A very desirable arrangement has been made during the year by the Institution in regard to the large collection of fossil plants brought in to the National Museum by the explorations of Dr. Hayden, Major Powell, Lieutenant Wheeler, &c., Prof. L. Lesquereux, of Columbus, Ohio, having agreed to receive the collection in mass, to pick out a reserve series for the Museum, and to bring all the duplicates of each species in separate packages, so that sets can be readily made up for distribution to the educational establishments and museums of the United States.

The material sent to Professor Lesquereux filled many boxes, and a portion of the reserve has already been returned to the Institution, although not yet unpacked for want of a place for its exhibition. The work will be completed with the publication of a report as soon as certain memoirs, now in press, are published, and it becomes possible to state the page and plate where each type specimen is illustrated.

A part of the agreement with Professor Lesquereux is for the preparation of a complete check-list of the fossil plants of America, to include Greenland and Alaska, to be used in connection with the proposed distribution of definite specimens and for the final arrangement of the reserve series.

Dr. C. A. White has been engaged upon the examination, classification, and registering of the paleontological collections, embracing those which have for many years been in the possession of the Museum, as well as those which have been more recently received, preparatory to their final arrangement in the new building. This work of investigation has embraced a more or less complete study of those forms which have been found to be new to science or otherwise of especial interest, and their publication and illustration in the Proceedings of the National Museum; and also, incidentally, the separation and labeling of the duplicate specimens for exchange. All the invertebrate fossils at present in the possession of the Museum have thus passed under a preliminary examination by Dr. White.

Among the results of the investigation of the invertebrate fossils may be mentioned the recognition of *Productus giganteus* Martin, in a collection obtained by the United States Fish Commission at McCloud River, Cal., which species was not previously known to occur in American strata; the recognition of *Stricklandinia salteri* and *S. davidsoni* Billings, among some Upper Silurian fossils brought from Northern Georgia by Lieut. A. W. Vodges, which two species had hitherto been found only in the island of Anticosti.

As already stated, the fossil plants have been referred to Prof. Leo Lesquereux for classification, which work is now in progress and in large part completed, the specimens as fast as they were labeled having been returned to the Museum. The greater part of the vertebrate fossils have not yet been investigated, but a considerable number of boxes received from Capt. G. M. Wheeler contain the types of vertebrate forms which were described and figured by Professor Cope in Volume IV Explorations and Surveys west of the 100th Meridian.

A large proportion of these paleontological collections, vertebrates invertebrates, and plants, consists of the type specimens upon which species and genera have been founded, and many other species and genera are represented among these collections by authentic examples. Among them are the types of the greater part of the species which have been published in the reports of the different explorations and surveys by authority of the general government, and by the Smithsonian Institution and National Museum.

The following is a list of the titles of the articles from the pen of Dr. White, based on the museum collections, which have been published in the Proceedings:

Descriptions of new species of invertebrate fossils.
Note on *Endothyra ornata.*
Note on *Criocardium* and *Ethmocardium.*
Descriptions of New Cretaceous Invertebrate Fossils from Kansas and Texas.
Note on the Occurrence of *Productus giganteus* in California.
Note on *Acrothele.*
Description of a New Cretaceous *Pinna* from New Mexico.
Note on *Stricklandinia salteri* and *S. davidsoni* in Georgia.
Description of a very large Fossil Gasteropod from the State of Pueblo, Mexico.
Descriptions of New Invertebrate Fossils from the Mesozoic and Cenozoic rocks of Arkansas, Wyoming, Colorado, and Utah.

Distribution of duplicate specimens.—It is a question whether any museum has ever made so systematic, thorough, and extensive a disposal of its surplus material as has been made by the Smithsonian Institution within the last twenty-five years. There is scarcely a public museum in the country, especially if connected with a scientific society, university or college, that has not received a share. In later years these distributions have been extensive including, as they have, the surplus stock gathered by the extensive operations of the United States Fish Commission.

An additional advantage connected with these distributions is the fact that nothing is ever sent out without being thoroughly identified and named by competent masters, so that the objects constitute types of the utmost value.

The extent to which this distribution has been carried during 1880 may be understood from the fact that it embraced over 14,000 specimens, each accompanied by labels showing name, locality, &c. The total number of specimens distributed to date is not much short of half a million (actually 407,255).

Assistants in the Museum.—A large appropriation was made by Congress for the service in the National Museum required by the erection of the new building, and available first in 1880. This required a reorganization of the entire force and a more specific definition of the duties and responsibilities to the Institution. All persons who had been employed received a specific letter of appointment, a condition of which requiring formal acceptance in writing was that the incumbent, during his connection with the Institution, should make no private collections in natural history of any kind whatever. This rule is in force in all the European museums, and is considered absolutely necessary for their interests, as the curators have ample opportunities of inducing the diversion of material from the museum to themselves, if they are so inclined. In the experience of the Smithsonian Institution there has been no reason to suppose that this danger is to be guarded against; but it was thought best to establish a general principle, so that there should be no misunderstanding at any time. All the persons appointed have agreed to the condition, which is now in full force.

Courtesies from Foreign Museums.—The authorities and trustees of the British Museum have been engaged for several years in the preparation and erection of new buildings at South Kensington, for the accommodation of the natural history collections, transferred from the location where they have been housed for so many years; and as it was presumed that the architects and curators of the museum would make a very exhaustive study in regard to what was needed for the exhibition of the specimens in the new building, application was made to Dr. Günther, the chief of the zoological department, for such information as he might feel at liberty to render. He kindly and promptly responded by sending numerous drawings and specifications, whichhave been carefully studied and made good use of in connection with the arrangements for the National Museum building.

The directors of the science and art branch of the South Kensington Museum have very kindly supplied a volume containing engraved plans and elevations of the glass cases of that establishment.

To Prof. A. B. Meyer, of Dresden, the Institution is also indebted for drawings of certain new iron cases lately erected in the Zoological Museum of that city. He added to the obligation also by having prepared and sent to us the elementary parts of the cases, of natural size, so as to furnish a better idea of the mode of construction and fitting.

THE ETHNOLOGICAL BUREAU.

As in previous years, an appropriation was made by Congress for the prosecution of researches into American ethnology in 1880, under the direction of the Smithsonian Institution. The superintendence of this work was continued in charge of Prof. J. W. Powell, the appropriation being expended partly in keeping up the office organization of the Bureau and partly in continuing the series of special researches into the ethnology and linguistics of the Indian tribes. A portion of the appropriation was also expended in continuing the explorations under the direction of Mr. James Stevenson into the ethnology of the pueblos of New Mexico. In 1877 a number of villages were visited and complete collections of everything illustrating their domestic habits, their weapons of war and the chase, their religious ceremonies, &c., were obtained. During the present year other villages were visited by the same parties, and large collections were made and shipped to Washington. These have not yet been received, but when they arrive will constitute a very important addition to the National Museum.

In addition to the general work prosecuted by Major Powell, he has been requested by General Walker to superintend the work of taking the census of the Indians for the census of 1880; and for this purpose he has appointed a number of agents to visit various portions of the United States for carrying out this business. Major Powell himself has spent a number of months in the field in connection with the same work.

RELATIONS OF THE INSTITUTION TO OTHER DEPARTMENTS AND ESTABLISHMENTS.

As shown by the past history of this Institution, its relations to the different departments of government and to numerous establishments in this and other cities have been varied and important.

The Government.—With the Library of Congress, the Institution is brought into constant intercourse, from the many contributions of valuable scientific works and journals continually made from donations, exchanges, purchases, and other sources. With the Army Medical Museum there is the exchange of anatomical objects for ot al and zoological specimens. With the Signal Office of the Wa her been interchanges of meteorological observat the Interior Department has naturally arisen a frequent communication relative to the material and information derived from the various government explorations and geological surveys. The Treasury Department has had occasion to institute investigations relative to the precise identification of manufactured and other articles, and the methods of detecting substitutions or adulterations, with special reference to customs duties and the prevention of fraud in the collection of revenue. With the United States Coast and Geodetic Survey, interesting relations have sprung up relative to certain features in physical geography. The scientific character of the National Observatory has naturally brought about an affiliation of the interests and purposes of the two institutions, and co-operation has been maintained especially with reference to the international transmission of astronomical discoveries by telegraph. To the custody of the Agricultural Department, the Institution has transferred from time to time all the entomological and botanical material coming into its possession from the contributions of its numerous correspondents.

Gallery of Art.—In conformity with the established policy of the Institution—"co-operation rather than competition"—it has made the Corcoran Art Gallery its depository of any works of fine art it may receive by exchange or otherwise.

A portrait which is claimed to be an original likeness of General Washington was sent to the Institution by Mr. E. C. Bruce, of Virginia, to be placed on exhibition in hopes of finding a purchaser at a satisfactory price. This portrait, said to have been painted by Mr. Polk, was, with the consent of the owner, deposited in the Corcoran Art Gallery, where it is now on exhibition.

In the early part of the year a letter was received from Mr. W. W. Evans, of New York, suggesting that communication be addressed to the Government of Italy for the purpose of obtaining some of the numerous duplicates secured by the latter in the progress of the excavations at Pompeii. In pursuance of the suggestion a correspondence was entered into, through the American minister in Rome, with the proper authorities in Italy. This is not yet concluded, but it is thought that whenever a suitable exchange can be offered on the part of the National Museum the desired object may be accomplished.

In connection with the subject of art, a favorable mention should be made of a life-size bust of Professor Henry, by Mrs. C. S. Brooks, of New York, now on exhibition in the Regents' room of the Smithsonian building. This bust, of considerable merit as a portraiture, is remarkable as having been modelled entirely from a photograph.

Polaris Expedition.—The history of the expedition of Capt. C. F. Hall in the direction of the North Pole, on the steamer Polaris, and its general results, have already been referred to in previous reports. As was to be expected, Congress made a liberal provision for the publication of the results of the expedition. The narrative volume was prepared under the supervision of Admiral Davis, at the time Superintendent of the Naval Observatory at this city, and the volume of physical results, prepared under the direction of Dr. Emil Bessels, the chief of the scientific corps of the expedition, and printed by Congress. There still, however, remains a large amount of material relating to the geology, natural history, and ethnology of arctic America, and Dr. Bessels has been continuing the elaboration of this work for publication, having a room in the building assigned for the purpose.

Congress at the last session made an appropriation of $8,000, and placed it under the direction of the Smithsonian Institution, to be expended in preparing this material for final publication. The supervision of the work was placed in Dr. Bessel's hands, and in order to complete his researches on the history of the Esquimaux, it became necessary for him to visit Copenhagen and have conference with Dr. Rink in reference to that branch, as also to study the collections in the Copenhagen Museum. He has been very sucessful in his mission, and expects to return in February, and immediately thereafter to begin the printing of his final report. By authority of the Secretary of the Treasury the disbursal of the funds was placed in charge of Mr. Thomas J. Hobbs, one of the disbursing clerks of the Treasury Department.

The Alaska Commercial Company.—For many years the Alaska Commercial Company has acted to a great degree as the agent of the Smithsonian Institution on the Pacific coast, and the heartiest acknowledgements are due for its assistance during the year 1880, as well as in previous years. It has not simply been the agent for the transmission or reception of packages between Washington and San Francisco, but has readily undertaken the purchase of supplies and their transmission to the agents of the Institution, in many cases making large money advances. The entire business has necessarily involved the employment of much official time, and in some cases doubtless considerable annoyance. This, however, has been cheerfully rendered by the company without any consideration whatever.

The company has also made many contributions to the Museum from the collections sent to it by its own agents.

Centennial Commission Archives.—In the latter part of 1880 a meeting of the executive committee of the International Exhibition of 1876 was held in Philadelphia for the purpose of closing up the business of the exhibition. It was then decided to deposit all the archives of the commission in the National Museum at Washington, and the Secretary of the Smithsonian Institution was notified of this action.

The value and importance of these papers, plans, &c., will increase with time, and the determination of the commission to secure for them permanent preservation at the national Capital is to be considered as patriotic and judicious. I have formally assured the commission of the willingness of the Institution to receive the articles as soon as a suitable place can be prepared in the new Museum for their reception.

National Academy of Sciences.—The regular meeting of the National Academy of Sciences was held in Washington on the 20th day of April, the accommodations being furnished, as in 1879, by the officers of All Souls' Church. It is hoped that at no distant day it may be in the power of the Smithsonian Institution to again offer the necessary facilities of room, &c., to the Academy. Prof. Wm. B. Rogers, president of the Academy, presided, and the meeting was in every way a successful one, a very large proportion of the members being in attendance and many interesting papers communicated. As the early history of the Academy was closely connected with that of the Smithsonian Institution, by reason of Professor Henry having been the president for many years, the files, correspondence, and archives were searched for data illustrating this relationship, and the results transmitted to Professor Rogers.

Paris International Congress and Exposition relative to Electricity.—Through the courtesy of the State Department, this Institution received early copies of circulars and programmes relative to a proposed international congress of electricians, and also to an international exhibition of electrical apparatus and applications, to be held at Paris in 1881. These papers have to some extent been appropriately distributed. By an official decree of President Grévy, of the French Republic, dated October 23, 1880, a congress of electricians is invited to meet at Paris on the 15th of next September (1881), the presiding officer of which body will be the minister of the postal service and telegraphs, M. Ad. Cochery. An international exposition of electrical apparatus of all kinds, designed for the production, propagation, and utilization of electricity (as well as of all memoirs and treatises relating to that subject) is appointed, to be held in the palace of the Champs Elysées, from the 1st of August to the 15th of November, 1881. M. George Berger has been appointed the commissioner-general of the congress and of the exhibition.

As a token of interest and co-operation in this enterprise, the Institution has sent to the commission, for deposit in the bibliographical class, a copy of each of its publications relating to electricity and terrestrial magnetism, to wit, four numbers of its octavo series (of Miscellaneous Collections), and thirteen numbers of its quarto series (of Smithsonian Contributions).

Recognition by Foreign Governments.—A gratifying testimonial to the appreciation of the Smithsonian Institution in its labors connected with the results of international exchanges, &c., was furnished by the action of the International Exposition in Sydney, Australia, in presenting to it a bronze medal, although no exhibit of any kind was made by the Institution on that occasion.

MISCELLANEOUS MATTERS.

Loss of Employés and Collaborators.—It is seldom that a year passes without entailing the mournful task of recording the loss by death of one or more of those who have been either directly employed by the Institution, or have rendered it assistance in the prosecution of its varied scientific operations. In the necrology of the past year, several valued names are to be included.

In the death of Dr. THOMAS M. BREWER, at his residence in Boston, on the 2d of January last, the Smithsonian Institution loses one of its best and earliest friends, and one who always rendered important service in his capacity as editor of a leading Boston daily journal, and did much toward keeping the public advised of the true spirit of the operations of the Institution.

In his death the science of ornithology loses one of its earliest votaries, constituting, as he did, a connecting link between the present epoch and the period of Audubon and Nuttall. Dr. Brewer's specialty was in his knowledge of the history and the habits of birds, and especially of their nidification, and he has always been the highest authority on everything relating to the eggs of North American species. Many years ago he planned an exhaustive work on North American Oology, to be illustrated by the best drawings that could be procured, and an agreement was made by the Smithsonian Institution to publish this work in successive parts. The first number of this North American Oology was published by the Institution, and embraced more particularly the rapacious birds, the swallows, the goat-suckers, and the king-fishers. This publication took place at a time when the knowledge of North American birds was undergoing many changes, resulting from the expansion of the territory of the United States and the better knowledge of its different portions.

The further publication was deferred for a time, but arrangements were being made at the time of his death to take up the work again and carry it to its completion.

Dr. Brewer has done a great deal towards popularizing American ornithology by his investigations and correspondence with ornithological students of all grades of advancement. To no one so much as to Dr. Brewer is due the love of ornithology that is so prevalent in New England. In 1840, he published an American edition of Wilson's Ornithology, which met for a time a much felt want, and he has also published a large number of papers on ornithological subjects. His most important work, however, was in connection with the History of North American Birds, by Baird, Brewer, and Ridgway, printed by Messrs. Little & Brown, in 1873, of which three volumes have so far appeared, namely, those on land species. Of these the entire biological text was furnished by Dr. Brewer. At the time of his death, he left behind the manuscript of the water-bird portion of the same history. This is now in the hands of Mr. Alexander Agassiz, and will probably be published soon as one of the remaining portions of the work.

Dr. Brewer had been throughout his life one of the chief supporters of the Boston Society of Natural History, of which, indeed, he was one of the founders, occupying year by year important posts in connection with the society; and his influence upon it cannot easily be overestimated.

After giving up his editorial connection with the Boston Atlas and Traveller, Dr. Brewer entered into business as a publisher and bookseller; and retiring from this a few years ago, he spent a year and a half in travelling in Europe, in the course of which he visited all the ornithological and oological establishments, and arranged special connections between their owners or the curators. Partly as the result of this visit, and partly of long-continued and persistent efforts, he became possessed of one of the finest general collections of eggs in the world, but especially rich in the North American species. These collections he caused to be passed over at his death to the Museum of Comparative Zoology of Cambridge, where they are safely preserved, and constitute one of the most striking features of that great museum.

The death of Mr. JAMES W. MILNER, which occurred at his residence, Waukegan, Illinois, on the 6th of January, 1880, was a serious loss to the science of fish-culture. Mr. Milner had been connected with the United States Fish Commission as assistant commissioner for many years past, having been in its service indeed, from the first year of its organization. He commenced his labors, as a collector of statistics in regard to the fisheries of the great lakes, the results of which appear in the reports of the commission. In later years he had had charge more particularly of the division of the propagation of food-fishes, in the course of which he invented or brought into use many important practical discoveries. In the course of his visits to different parts of the country he also took occasion to make extensive collections in natural history for the National Museum, all of which are recorded in its catalogues.

Mr. Milner's illness was induced by a severe cold (taken in the spring of 1878,) which assumed a malarial tendency, and required his return to Lake Michigan for recuperation. He again assumed charge of his work in the autumn of that year, organizing the arrangements for the hatching of codfish by the United States Fish Commission at Gloucester, in the months of October and November. His increasing indisposition, however, made it necessary for him to go to some other locality, and he returned to Washington, and after spending a short time he went to Florida, where he remained during the winter.

He returned to Waukegan in the spring of 1879; but this season was exceptionally raw and trying on the lakes, and by the direction of his physician he visited Colorado for the summer. He, however, failed to improve, and was brought to Waukegan in the autumn, and after much suffering died, as stated, on the 6th of January, 1880.

A man of modest and agreeable demeanor, Mr. Milner, by careful observation and study, had mastered the theory and practice of fish-culture, and had himself made many important improvements. His loss to the Fish Commission is one which it will be extremely difficult to replace.

Mr. J. HOMER LANE must be mentioned as a valued collaborator of the Institution, who died in this city May 3d of the past year. A graduate of Yale College, he commenced his career as a teacher. His high scientific and mathematical attainments having become known to the Superintendent of the United States Coast Survey, he was early appointed to a position in that branch of the public service. About the year 1847, on the recommendation of Professor Henry, Mr. Lane was transferred to the United States Patent Office, as opening to him a more varied and active occupation; and he discharged the responsible duties of an Examiner in that institution with a pains-taking fidelity for many years. On the death of Mr. Saxton, who had charge of the construction and verification of the national and metric standards (under the Coast Survey Office), Mr. Lane was recalled to that bureau to fill this vacancy,—a position held by him till his death.

Mr. Lane had given considerable attention and study to the mathematical theory of electricity, and in 1859 he conducted, at the request and under the general supervision of Professor Henry, a series of experiments for this Institution, on several points of scientific interest relating to the Atlantic telegraph, a brief notice of which investigation was given in the Smithsonian Report for 1859, p. 38. To Mr. Lane was also occasionally referred, for examination and report, communications or memoirs requiring for their thorough treatment a special familiarity with the higher mathematics. In 1866, he undertook an elaborate investigation into the conditions of successive expansion or rarefaction in gases, having particularly in view a more precise determination of the absolute zero of temperature. In these experiments he was assisted by apparatus specially constructed for him by the Institution. His fastidious desire for extreme accuracy led him to postpone the publication of results until it is feared that the valuable work actually accomplished by him in this direction will not be available for the promotion of knowledge among men, to which purpose he had so long and earnestly devoted himself. Mr. Lane was remarkable for the logical clearness of his mind and the strict conscientiousness of his moral nature.

When Mr. William H. Dall returned, in 1873, from his labors in Alaska, under the direction of the United States Coast Survey, he brought with him a young Aleute, named GEORGE TSAROFF, who commended himself to him by his intelligence. With the aid of some persons interested in education, Mr. Dall secured for his protégé an excellent education in Michigan, in the course of which he learned to read, write, and speak the English language with great readiness. On completing his course of education, he was brought to Washington as an assistant, and placed in charge of the large ethnological hall in the second story of the building, his duties being to keep everything in order and to act as a guide to visitors. These he performed with efficiency, himself constituting an extremely interesting exhibit—that of a native Indian, well educated and instructed, and able to explain the special objects and applications of many articles manufactured and used in his own country.

I regret to say that this interesting assistant was attacked by consumption, and for greater convenience of careful treatment, he was removed to Providence Hospital on the 2d of March, where he died on the 8th of May.

Among the deaths of those deserving special notice in this report is that of Mr. WILLIAM Q. FORCE, who for many years had charge of the meteorological department of the Institution. He was the son of General Peter Force, of Washington, at one time mayor of the city, and well known for his devotion to the study of American history. His collection of books in this department was the largest in the country, and was purchased by the government for the Library of Congress. In the collection of these books and in the preparation of the "American Archives" Mr. William Q. Force was the principal assistant of his father. He also edited and published the "Army and Navy Chronicle and Scientific Repository," and several works relating to history and statistics. He graduated at Columbian College in 1839, studied law, and in 1857 took charge of the meteorological department of the Smithsonian Institution, discharging the duties of the position for eleven years with marked fidelity and ability. He resigned on account of an attack of illness, which caused a permanent derangement of his nervous system, and he devoted the remainder of his life to literary pursuits and to quiet and unobtrusive deeds of charity.

He held several important positions of honor and trust in connection with religious and educational enterprises and establishments, in all of which he was noted for his scrupulous honesty, purity, and fidelity. In all the relations of life he was a noble example of a man wholly actuated by Christian principle, and whose practice conformed rigidly to his professions.

Berendt manuscripts.—The long-continued labors of Dr. CARL HERMANN BERENDT, in Mexico and Central America, relating to the ethnology and philology of the native tribes, prosecuted to a certain degree under the auspices of the Institution, have been detailed in its previous reports at various times within the last twenty years and more; and it is with great regret that I have to announce the death of that gentleman in the city of Guatemala on the 12th of April, 1878.

He left his valuable manuscripts and rare books with Mr. B. Westermann, of New York, and many similar articles were in his own rooms in Guatemala. These, by an arrangement with his executor, Mr. Westermann, were gathered together by Mr. Francis Sarg, a fellow countryman, who was also a resident of Guatemala; and by the kind mediation of Capt. John M. Dow, forwarded to the Smithsonian Institution, filling five boxes.

An inventory of this property was made by the Institution and transmitted to Mr. Westermann, who also had prepared a catalogue of the first collection, the whole of which constitutes a very important mass of historical and scientific matter, both in print and manuscript; and it is to be hoped that some arrangement may be made by which this can be added to some public library in the country, and no better depository could be found than the Library of Congress.

Although engaged for many years in the researches referred to, Dr. Berendt had printed but little, so that unless his manuscripts are carefully edited and published, his life work will have left but little on record. With an assurance of long life and an ultimate opportunity of publication, a feeling not uncommon among literary men, Dr. Berendt allowed the opportunity of presenting his labors to pass while aiming at further perfection.

Donations.—A large fire-proof safe was presented to the Institution for the National Museum by the Herring Safe Company of New York; a notice of which was given in the last Report. This safe has just been received, and is an admirable specimen of the well-known skill of this enterprising company. It stands about seven feet high, and by its fine finish forms an attractive piece of furniture. It will prove a very useful receptacle for small objects of special rarity and value belonging to the Museum.

Mention should be made of several other contributions of interest. One of such has been a pair of Howe scales, presented by Messrs. F. P. May & Co., of Washington, the agents of the Howe Company. These scales have been placed in the entrance hall of the Institution, and are constantly in use for weighing visitors.

Among the contributions to the Institution of a miscellaneous character during the year is that of a hydro-pneumatic fire-extinguisher, presented by the agent of the company in Washington. This is claimed to possess specially valuable qualities which fit it for practical use in public and private establishments, and is kept in order for ready application should an emergency requiring it arise.

Of the works published by the United States Government during the last few years none has had more popularity than the narrative of the second arctic expedition made by Capt. C. F. Hall, edited by Prof. J. E. Nourse. Congress has ordered several editions of this work and placed copies of it for sale at the mere cost of paper and printing. In this work illustrations are given of Esquimaux life, manners, and customs, the articles represented being specimens in the National Museum. During the last year the Secretary of the Navy has offered to the Institution the manuscripts, notes, plates, cuts, &c., of Captain Hall's work to be preserved in its archives.

Loan of books and apparatus.—The Smithsonian Institution has been proverbial, from its first establishment, for the liberality with which the use of books, apparatus, and specimens has been allowed whenever required in the interest of science, the regulations of many institutions absolutely prohibiting the removal from their halls of such articles, not being at all enforced. It was found necessary, however, to establish some restrictions to the indiscriminate borrowing, as it was ascertained that in many cases the borrower was careless about returning the objects obtained by him, so that when others required their use they were not available for the purpose. In some instances rare volumes of transactions of learned societies would be kept for years, and not unfrequently an entire set would be returned after the death of the borrower; in other cases, when called for, the report would be that they were not producible.

In order to throw upon the borrower the onus of making a proper return without unnecessary delay, Professor Henry decided to require a deposit in money, or a certified check, far in advance of the value of the object itself; in the case of the loan of a volume of transactions the money security called for representing the value of the entire series. This condition has given offense in some cases, persons thinking that the deposit should be simply of a money value equal to the value of the article borrowed. This, however, would not answer the purpose, as, in many cases, individuals would be glad to obtain a rare work at cost; and as the Institution is not engaged in trade and needs its books and apparatus for its own research, and that of its collaborators, the propriety of the regulation has, I think, been fully vindicated. The required deposit for books amounts, generally, to from $25 to $100, and of course the borrower, whose money is in the hands of the Institution, does not leave it there longer than is necessary. When the book is returned the money is sent back and the transaction closed. This same regulation has been extended to the loan to parties of other articles having a definite money value.

Loan of specimens.—As far as specimens of natural history are concerned the regulations are arranged on a different footing; and as a further means of preserving the integrity of the Smithsonian collections, the following form of "receipt" from naturalists who may borrow its material, has been adopted by the Institution:

[Locality ——Date ——]

"Received from the Smithsonian Institution a collection of ——, corresponding to the accompanying list. I hereby accept them in trust upon the following conditions: First. That they are to be used for purposes of investigation, and returned in as good condition as they were received, and as soon as my work upon them is completed. Second. That no unique specimens constituting part of the reserve series of the National Museum shall be mutilated. Third. That duplicates when necessary may be dissected; understanding by 'duplicate,' a specimen which is not necessary to illustrate variations of forms or range of geographical distribution. Fourth. That the specimens when returned shall be labeled with the names which I have employed in my publications upon them. Fifth. That credit shall be given to the Smithsonian Institution in all publications based upon material furnished by it."

[Signature of borrower.]

Restoration of the Declaration of Independence.—Several years ago a commission was appointed by Congress (under an act approved August 3, 1876), consisting of the Secretary of the Interior, the Secretary of the Smithsonian Institution, and the Librarian of Congress, for the purpose of taking into consideration measures for the restoration of the faded and now nearly illegible Declaration of Independence. Some conferences were held on this subject and some experiments made in regard to it, but without result. A meeting of the commission was held at the Department of the Interior on the 5th of May last, and, after discussion, it was decided that it was one of the subjects coming within the province of the National Academy of Sciences, and the problem was referred to Professor Rogers, president of the Academy, with the request to appoint a commission of scientific experts to investigate the whole subject and report to the Secretary of the Interior. No return has yet been made by this commission, but it is understood that the matter is receiving careful consideration.

UNITED STATES FISH COMMISSION.

GENERAL OBJECTS AND RESULTS.

The relationship which your Secretary has borne for ten years to the United States Fish Commission as its chief, and the time required for the discharge of its responsibilities, makes it proper to furnish a brief statement of the objects and results of the commission, as showing thereby that its operations are quite in accordance with the purposes of the Smithsonian Institution.

The inception of the commission, on a very small scale, in 1871, and the rapid extension of its operations year by year, have all been chronicled in the annual reports of the Institution; and now that ten years have elapsed, the reports of the commission will, I trust, show its healthy growth and a successful accomplishment of some, at least, of the objects which have been kept strictly in view from the outset.

As explained in previous reports, the commission was first established, in 1871, for the purpose of investigating the alleged decrease of the food-fishes of the country, and of inquiring as to the best methods of remedying the decrease, should this be found to exist. It was not until the second year, or 1872, that the responsible duty of increasing the supply was added to the other functions of the commission.

In the preceding report of the Smithsonian Institution, for 1879, I have stated at length the plans and objects of the commission, and to this I refer for details. I may simply remark here that the division of "inquiry" has been held to involve a complete investigation of and report upon all the physical conditions of the waters of the United States, and the nature, numbers, and general relationships of their inhabitants, together with an account of the relationships of man to the same, in the way of methods and appliances of the fisheries, and the history and statistics of his labors.

The second division, that of propagation, of course includes the protection of the useful fishes and their multiplication, either by capturing the fish and transferring them from one point to another, or by the process of artificial impregnation of the eggs and the distribution of the young.

The work of the inquiry is prosecuted, for the most part, directly under my own supervision, from stations at different points along the seacoast, with a suitable number of assistants (volunteers for the most part) for making the investigations referred to. The specimens collected are placed in the hands of experts, by whom they are properly investigated and monographed, and the results published, with suitable illustrations in the Annual Reports of the Commission. The collections made, usually in very large numbers, are worked up at the same time; the reserve collection preserved in the National Museum, and the duplicates distributed to the various educational establishments of the country, or exchanged for objects desired by the Museum.

The propagation division is conducted either at some permanent stations, such as those of the salmon, whitefish, and carp, or in temporary establishments, shifting their ground with the season, as is the case in large part, with the shad stations.

During the past year two additional subjects have occupied the attention of the Commission; one, the preparation for the international display of the fisheries of the United States at Berlin; and the other, the continuation of the census of the fisheries, undertaken in behalf of General Walker, Superintendent of the Census. Special details in regard to these branches will be found elsewhere.

Newport was the station selected for the prosecution of the work of inquiry into the fisheries in 1880, as representing a point between two previous stations, Wood's Holl and Noank. Since the year 1873 the Commission has been indebted to the Navy Department for a steamer with which to carry on its investigations. This year, however, it was found possible to dispense, in large part, with extraneous aid, the *Fish*

Hawk,* the vessel referred to in a previous report, having been completed and ready for sea.

Her original purpose was that of a floating hatching establishment; but she was not completed until some time in July, or after the spring hatching work was over. Her first service, therefore, was in the inquiry division of the Commission. She is a vessel of 484 tons, and provided with all the necessary conveniences for investigation, such as a powerful hoisting engine and the necessary dredging and trawling apparatus. She proved admirably adapted to the requirements of the occasion.

Her *personnel* was furnished by the Navy Department, under the law of Congress that directed that she be placed on the same footing as the vessels of the Coast Survey, which gave her the officers and a crew, with their subsistence, leaving to the Commission the running expenses, such as the cost of coal, oil, water, etc. Lieut. Z. L. Tanner, who had been in charge of the steamer *Speedwell*, at Provincetown, in 1879, was placed in command by the Navy Department, with Mr. J. S. Smith as mate, Wm. B. Boggs as engineer, Geo. H. Reed as paymaster, and F. C. Van Vliet as surgeon, and a crew of 27 men.

A large building, formerly used for the manufacture of shot, was rented from Mr. John H. Griswold; an adjacent wharf, with a number of buildings upon it, was also obtained for the service of the Commission.

As in previous years, the superintendence of the work connected with the marine invertebrates was in charge of Professor Verrill, of Yale College, assisted by J. H. Emerton as artist, Mr. Sanderson Smith of New York, and Mr. B. F. Koons and E. A. Andrews. Mr. Richard Rathbun was an assistant of the Commission in the general work, and Mr. H. L. Osborn and Frederic Gardiner had charge of the fishes during the absence in Alaska of Dr. T. H. Bean.

The census branch of the fisheries also had its quarters in the town.

My own office, those of the laboratory and of the census, and the residence of Maj. T. B. Ferguson, assistant commissioner, were connected by telephone, for the more convenient transaction of business.

I arrived in Newport with my party on the 9th of July, and was joined by Professor Verrill a few days later. The steamer, however, did not reach Newport until the 2d of August, and, owing to various causes, did not get fairly at her work until about the 7th. The city wharf was hired from the city of Newport, where she lay when in port. The work was carried on with great zeal during the summer, and very important discoveries, both scientific and practical, were made, especially in the course of three visits to the Gulf Stream in September and October. On these occasions, the vessel by starting in the evening at 6 o'clock, and running out to a distance of about a hundred miles reached the Gulf Stream, and explored it for a period of 12 to 14 hours, and returned to port on the succeeding night. The amount of life found along the western edge of the Gulf Stream was enormously rich; of mollusca, not less than 175 different species were taken, forty being new to science. Twenty new deep sea fishes, some of them of a remarkable character, were secured. The most important observations, however, were those in regard to the Tile fish (*Lopholotilus chameleonticeps*), to which reference was made in a previous report. The ascertained range of this fish was greatly extended, showing the possibility of capturing it over a wide area.

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*This vessel was designed by Mr. C. W. Copeland, of the Light-House Board, and built under the direction of the Light-House Board, and the immediate supervision of Mr. Copeland and Lieut. Z. L. Tanner, U. S. N.

For the purpose of determining the ability to take this fish with an ordinary fishing smack a Noank vessel was chartered for the trial. Owing to a threatening storm, however, the vessel was compelled to return, and nothing was done beyond the capture on a small line of an enormous sword-fish.

Mr. G. Brown Goode, who had represented the United States at the Berlin Exhibition, returning, joined the party on the 17th of July and was, for the most part, occupied in connection with the fishery census.

During the summer I visited Wood's Holl in the *Fish Hawk*, for the purpose of inquiring into the possibility of making a station at that point, for the hatching of codfish.

The work of the Commission at Newport was closed about the beginning of October, and on the 7th of that month the *Fish Hawk* returned to Wilmington for some additional apparatus, carrying a portion of the collection to New Haven, by the way, for the use of Professor Verrill. After taking on board further hatching apparatus, the steamer came around to Washington, cruising along the edge of the Gulf Stream on her route, and making additional collections of importance.

I left Newport with my party on the 8th of October, closing operations for the season at that place.

The control of so well equipped a steamer as the *Fish Hawk* and the several visits to the Gulf Stream resulted in the acquisition of a large amount of material, equal almost to the aggregate of all our preceding seasons. This has been put in hand and will, as rapidly as possible, be examined, the reserve series added to the collection of the National Museum, and the remainder distributed as heretofore.

In the Report of the Institution for 1879 reference was made to the operations of the Fish Commission in connection with the artificial propagation of codfish at Gloucester, Mass. This work was continued into the beginning of the year 1880 and a large number of fish hatched out and liberated. These have remained for a considerable time in the harbor of Gloucester and its vicinity, and by their abundance and unusual appearance attracted much attention.

The work of cod hatching was again undertaken in the winter of 1881, in the little harbor at Wood's Holl, Massachusetts. Facilities were granted by the Light-House Board at its depot; the machinery was erected and everything in readiness for the work. The unusual severity of the winter, however, which froze up the shores, rendered it impossible to keep the fish in their pens, and prevented any measure of success. It is hoped that during normal seasons the propagation of the cod may be considered as a perfectly feasible undertaking, and one promising important economical results.

The operations of the Commission in connection with the hatching of shad have also been of increasing importance during the year. The work was commenced in Albemarle Sound, North Carolina, and many millions of fish were hatched out. A station was then established on the Potomac River. By the courtesy of the authorities of the Navy Department, and especially of the Chief of the Bureau of Yards and Docks, a hatching station was extemporized for hatching out the eggs of the shad obtained by the steamer Lookout from the seines and gilling stations down the Potomac, especially in the vicinity of Fort Washington.

Another station was made at Havre de Grace, Maryland, and at the two places about 30,000,000 shad were successfully hatched out. A large proportion of these were necessarily placed in the rivers whence the eggs were obtained. Many millions, however, were distributed by the messengers of the Commission to various localities throughout the United States, especially to the waters of the Mississippi Valley.

The propagation of the *Salmonidæ* has also been conducted with satisfactory results. The McCloud River station, for the cultivation of the California or Quinnat salmon, was in successful operation, and furnished many millions of eggs, which were distributed, as usual, to all parts of the United States. Some of these eggs went to Germany, France, and Holland, where they arrived in good condition, and were hatched out very satisfactorily.

After an interval of several years, work was resumed at the station on the Penobscot River for obtaining the eggs of the Penobscot salmon, and a distribution of these fish was made to the principal rivers of the Northern and Eastern States.

An unusually large gathering of eggs of the land-locked salmon was made at the station on Grand Lake Stream, this fish promising to be of great value in the cold, deep lakes of the country.

Work on a large scale in connection with the white-fish of the great lakes was commenced this year by establishing a station at Northville, Michigan, under the charge of Mr. Frank N. Clark. With the necessary number of assistants, Superintendent Clark obtained a bountiful supply of eggs in the adjacent lakes, and gathered into the hatching-house about 13,000,000. Some of these were distributed to different parts of the country; but by far the greater part were hatched out and placed partly in Lake Michigan, partly in Lake Huron, and partly in Detroit River.

An interesting experiment was made in the artificial propagation of the striped bass or rock-fish of the Southern States—the eggs from a gravid female having been properly impregnated, a large number of young were hatched out. This experiment, it is hoped, will be continued in future years on a much larger scale.

Perhaps the most important result of the work of the Commission in the line of the propagation of fish is that of the multiplication and distribution of the imported German carp, of which, as already explained, there are three principal varieties—the scale, leather, and mirror carp. The distribution of the young of these fish was commenced in the autumn of 1879. A very large yield in 1880 permitted them to be sent to a great many applicants throughout the country, some thousands in number. The demand, however, is increasing, and is likely, for some time, to more than keep pace with the supply. It is gratifying to know that the efforts of the Commission to introduce this fish meet with favorable recognition.

An account of the operations of the United States Fish Commission during the first decade of its existence, detailing somewhat fully its plan of work, and the scientific and economical results accomplished by it, was prepared by Mr. G. Brown Goode, and read before the American Association for the Advancement of Science at its Boston meeting, held August 28, 1880. This paper will be found in full in the appendix to this report.

FISHERY CENSUS OF 1880.

In July, 1880, an arrangement was made with General Francis A. Walker, Superintendent of the Tenth Census, by which an investigation of the fisheries of the United States was undertaken as the joint enterprise of the United States Fish Commission and of the Census Bureau. It was decided that this investigation should be as complete as possible, and that both the United States Fish Commission and the Census Bureau should participate in its results. The preparation of a statistical and historical report upon the fisheries, to form one of the series to be presented by the Superintendent of the Census as the result of his investigations in 1880, has been the main object of the work; but in connection with this statistical work, extensive investigation into the methods of the fisheries, into the distribution of the fishing-grounds, and the natural history of useful marine animals, has been and is being carried on.

The direction of this investigation has been placed in the hands of Mr. G. Brown Goode, who was appointed agent of the Census Office, and who has been carrying on this work in addition to the performance of his duties in connection with the National Museum. The work which was begun on July 1, 1879, has been vigorously prosecuted since that time, and the final report will probably be presented as early as July, 1881.

The plan of the investigation was drawn up before the beginning of the work and has been published in an octavo pamphlet of 54 pages, entitled "Plan of Inquiry into the History and Present Condition of the Fisheries of the United States." Washington: Government Printing Office. 1879.

The scheme of investigation divided the work into the following departments:

I. *Natural history of marine products:* Under this head was to be carried on the study of the useful aquatic animals and plants of the country, as well as of seals, whales, turtles, fishes, lobsters, crabs, oysters, clams, &c., sponges and marine plants and inorganic products of the sea, with reference to geographical distribution; size; abundance; migrations and movements; food and rate of growth; mode of reproduction; economic value and uses.

II. *The fishing-grounds:* Under this head are studied the geographical distribution of all animals sought by fishermen and the location of the fishing-grounds, while with reference to the latter are considered: location; topography; depth of water; character of bottom; temperature of water; currents; character of invertebrate life, &c.

III. *The fishermen and fishing towns:* Here are considered the coast districts engaged in the fisheries with reference to their relation to the fisheries, historically and statistically, and the social, vital, and other statistics relating to the fishermen.

IV. *Apparatus and methods of capture:* Here are considered all the forms of apparatus used by fishermen, boats, nets, traps, harpoons, &c., and the methods employed in the various branches of the fishery. Here each special kind of fishery, of which there are more than fifty in the United States, is considered separately, with regard to its methods, its history, and its statistics.

V. *Products of fisheries:* Under this head are studied the statistics of the yield of American fisheries, past and present.

VI. *Preparation, care of, and manufacture of fishery products:* Here are considered the methods and thev arious devices for utilizing fish after they are caught, with statistics of capital and men employed, &c.: preservation of live fish; refrigeration; sun-drying; smoke-drying; pickling; hermetically canning; fur dressing; whalebone preparation; isinglass manufacture; ambergris manufacture; fish-guano manufacture; oil rendering, &c.

VII. *Economy of the fisheries:* Here are studied financial organization and methods; insurance; labor and capital; markets and market prices; lines of traffic; exports, imports, and duties.

VIII. *Protection and culture:* This includes all kinds of supervision by the government, such as legislation; bounties and licenses; fishery treaties; public fish culture.

The various inquiries provided for in this scheme of investigation have been made in three ways.

First. By correspondence with persons in different parts of the country.

Second. By a systematic overhauling and compilation of past records, not the least among which are the local newspapers.

Third. By sending special agents to make personal inquiries in every part of the United States where the fisheries are of considerable importance.

The last-named method has of course been by far the most important and the most successful, and it is unfortunate that the length of time and the amount of money available have not permitted the employment of a larger number of assistants in this branch of the work, and have not allowed them to devote as much attention to working out specific questions as has in many cases seemed imperatively necessary.

The fishery industry is of such great importance and is undergoing such constant changes that a visit of a few days, even by the most competent experts, has invariably proved unsatisfactory. They have been able to collect only the more important facts, leaving many subjects of interest untouched.

The field work has been carried on by the following special agents: (1.) Coast of Maine, east of Portland, R. E. Earll and Capt. J. W. Collins. (2.) Portland to Plymouth (except Cape Ann) and eastern side of Buzzard's Bay, W. A. Wilcox. (3.) Cape Ann, A. Howard Clark. (4.) Cape Cod, F. W. True. (5.) Provincetown, Capt. N. E. Atwood. (6.) Rhode Island and Connecticut, west to the Connecticut River, Ludwig Kumlien. (7.) Long Island and north shore of Long Island Sound and west to Sandy Hook, Fred. Mather. (8.) New York City, Barnet Phillips. (9.) Coast of New Jersey, R. E. Earll. (10.) Philadelphia, C. W. Smiley and W. V. Cox. (11.) Coast of Delaware, Capt. J. W. Collins. (12.) Baltimore and the oyster industry of Maryland, R. H. Edmunds. (13.) Atlantic coast of Southern States, R. E. Earll. (14.) Gulf Coast, Silas Stearns. (15.) Coast of California, Oregon, and Washington, Prof. D. S. Jordan and C. H. Gilbert. (16.) Puget Sound, James G. Swan. (17.) Alaska seal fisheries, Dr. T. H. Bean. (18.) Great Lakes fishery, Ludwig Kumlien. (19.) River fisheries of Maine, C. G. Atkins. (20.) The shad and alewife fisheries, Col. Marshall McDonald. (21.) Oyster fisheries, Ernest Ingersoll. (22.) Lobster and crab fisheries, Richard Rathbun. (23.) Turtle and terrapin fisheries, F. W. True. (24.) The seal, sea elephant, and whale fisheries, A. Howard Clark.

In addition to the field assistants already mentioned, a staff of assistants from the beginning have been at work in the office of the division, carrying on correspondence, searching past records, and preparing the report for publication. Mr. C. W. Smiley, Mr. Jas. Temple Brown, and Mr. George S. Hobbs have been connected with the work from its start, and from a later date Mr. J. E. Rockwell, Mr. C. W. Scudder, Mr. R. I. Geare, Mr. G. P. Merrill and others have been thus employed. A number of clerks have also been detailed for this work by the Superintendent of the Census, at one time as many as eight. A large part of the clerical force is under the direction of Mr. C. W. Smiley, who has in special charge the correspondence and the statistical and compiling work.

Mr. William H. Dall, of the United States Coast and Geodetic Survey, was detailed by the Superintendent, Captain Patterson, to visit Alaska and the Arctic Ocean, for the purpose of obtaining information in regard to the Alaska coast, a work upon which Mr. Dall has been engaged for many years. Permission for Dr. Bean to accompany Mr. Dall was readily obtained from Captain Patterson, and the voyage from San Francisco was made in the schooner *Yukon*, of the Coast Survey, a vessel originally built under Mr. Dall's direction for service in the Alaskan waters.

Mr. William J. Fisher, tidal observer at Kodiak, also contributed important material of the same general character. As the result of these several explorations, over one hundred boxes and packages of natural history collections have been received by the Institution, all more or less incidental to the census inquiries made by the same parties.

One of the most important reports of Dr. Bean's investigations was the discovery that cod and halibut of the Alaskan waters were identical with the same species as those in the North Atlantic, and consequently all the conditions of pursuit and preservation used in the east could be employed appropriately in the western seas.

BERLIN INTERNATIONAL FISHERY EXHIBITION.

Among recent organizations in Europe for the purpose of developing home industries, one of the most important is the *Deutsche Fischerei-Verein*, founded in 1871, for the purpose of developing the fisheries of Germany, both inland and maritime, and of introducing improved methods of fish culture and new varieties of fishes. The organization is composed of some of the most eminent naturalists and pisciculturists of Germany, and also includes many personages of the highest rank in the empire who are most interested in the welfare of the State.

For the purpose of bringing together a display illustrating the methods and results of the fisheries and fish culture of the Old World, arrangements were made for holding an international fisheries exhibition in Berlin in the spring of 1880, and invitations were issued about eighteen months before, asking the co-operation of governments, associations, and persons interested generally. The invitation to the United States to participate was transmitted to the Secretary of State in the winter of 1878–'79, but no action was taken by Congress. This was a source of great regret to the German Government, as well as to the immediate promoters of the enterprise, and urgent appeals were made through the German and American ministers for action. A second communication made by the Secretary of State about the beginning of 1880 was more successful, a bill introduced by Mr. Deuster, member of the House from Michigan, being readily passed, appropriating $20,000 to enable the United States Fish Commission to make the exhibition on the part of the United States.

I was called to appear before the Senate Committee on Foreign Relations on the 10th of February, and explained the proposed display, and gave some reasons why it would be to the interest of the United States to participate in it. The Senate committee reporting favorably, the bill became a law, and appropriations were made to carry out its provisions.

My duties in connection with the Smithsonian Institution, the National Museum, and the Fish Commission made it impossible for me to attend the exhibition, and Mr. G. Brown Goode, the curator of the Museum, was appointed as the commissioner in charge, and immediate preparations were commenced for the occasion.

Of course the time for preparation was very short, as the exhibition was to be opened on the 20th of April, giving nearly eighteen months less time than that enjoyed for the purpose by most of the other participants. Fortunately, however, the components of the exhibition of the fishery and fish-cultural interests of the United States made at the International Exhibition of 1876 at Philadelphia were available for the purpose, and a selection from these was made by Mr. Goode, with the assistance of Mr. True, and invitations for contributions of later material were promptly responded to. The most important possible additions to the display of 1876 consisted in the improved apparatus for fish culture, and in the samples of preparations of prepared fish, both having made vast progress during the intervening four years.

The United States Fish Commission proposed to display, either in original apparatus or in models, the new methods of hatching fish with the assistance of steam power, as devised by Mr. T. B. Ferguson, of the Fish Commission, and especially to show the model of the new fish-hatching steamer *Fish Hawk*, to be used as a floating hatching establishment in the propagation of shad and other useful fishes. The model of the new vessel was on a scale of about half an inch to the foot, and that of the fish-hatching apparatus on a scale of one-sixth the actual size. An enormous number and variety of samples of mackerel, cod, smelts, crabs, oysters, lobsters, and other marine products were supplied in the different forms of dried, powdered, salted, smoked, and canned, either in oil or in spices. Certain firms were invited to furnish their special apparatus for the capture of fish, and no time was lost in making use of the short interval remaining. This work was carried on so successfully under Mr. Goode's administration that it became possible to ship a first load, of some thousands of cubic feet, on the 28th of February, the last of the lot being transmitted on the 24th of March. The total amount of freight thus sent forward consisted of about 12,000 cubic feet.

With most commendable liberality, the North German Lloyd Co., at the suggestion of its agents in New York, Messrs. Oelrichs & Co., agreed to transmit and return all the packages of the Commission free; and not to be behind a foreign corporation in this spirit, the great lines of roads between Washington and Baltimore and New York, namely, the Baltimore and Ohio, the Baltimore and Potomac, the Philadelphia, Wilmington and Baltimore, and the Pennsylvania, agreed likewise to carry the packages free. The greater part of the exhibit of the United States was shipped from Baltimore by the Bremen steamers, although most of the packages concentrated at New York were embarked from that city, as also Mr. Goode's immediate staff, consisting of Mr. F. W. True and Mr. J. E. Rockwell of his office force, with Mr. Fred Mather, expert n fish culture, Capt. J. W. Collins, expert in fisheries, and Mr. Joseph Palmer in charge of the models and casts. Mr. Goode left Washington on the 16th of March and sailed in the Bremen steamer *Neckar* on the 20th, the company granting a concession of one-fourth of the fare.

A large portion of the goods were found in Bremen on the arrival ot the party, and these were sent forward to Berlin and unpacked in time for very satisfactory opening of the Exhibition on the 20th of April. Some smaller collections, sent at a later date, were received subsequently. A large amount of space had been assigned to the United States, but this being inadequate a portion of that granted to Great Britain, and not occupied by her exhibitors, was added. The section of the United States was ornamented by a large number of flags lent for the purpose by the Navy and War Departments, and the display as a whole was very effective.

It is now a matter of history that the United States bore off the chief honors of the occasion, the superlatives of the critics being exhausted in their praises of its method, richness, and great intrinsic value. Indeed the entire collection of the remaining portion of the International Exhibit of Fish and Fisheries would not have made a single exhibit of anything like the importance of that of the United States. In illustration of this fact it may be stated that the grand prize given by the Emperor of Germany to the Exhibition, for the best display, was awarded to the United States. This consisted of a large vase, three feet high, beautifully worked in silver and gold, and costing over $2,000. In addition to the grand prize there were numerous other awards in the way of medals of gold, silver, and bronze to contributors from this country, and the number of these awards would have been much greater but for the fact that the greater part of these contributions were made as part of that of the United States Fish Commission. The same policy was pursued there as at the Philadelphia exhibition; where objects were presented to the Institution and to the United States, they were entered for special consideration as individual exhibits; but where they were purchased for the exhibition they became the property of the United States, and their individuality was lost in the general display. Many persons who preferred to receive the comparatively slight money-value of the objects obtained from them, were greatly disappointed on finding that, however meritorious, their articles were passed over by the judges and no awards made for them.

It was originally supposed that the exhibition would close on the 1st of June, after a six weeks' display. Very much interest, however, was felt in the display, and it was so much more successful than had been expected that it was concluded to keep it over until the 1st of July. This involved an additional four weeks' detention of the party, and of course increased the expense. Thanks, however, to Mr. Goode's careful administration, I am happy to say that the work was finished and all the exhibits returned to Washington within the appropriation, a few dollars having been paid into the Treasury as the surplus. Owing to the care with which the articles were packed, everything arrived in perfect condition at its destination; indeed, out of the large number of plaster casts very few required any treatment for their proper exhibition. This was in marked contrast to the experience of the British portion of the exhibit, which, although it was much smaller in extent, was almost utterly destroyed in transit.

Acting under his instructions, Mr. Goode disposed of some of the more bulky and least costly articles, such as the whale boat and a number of the dories, &c., to various governments and other establishments in exchange for desired objects belonging to the European divisions. This somewhat reduced the bulk of the shipment, but not very greatly. The entire lot of at least 10,000 cubic feet was brought by a single vessel of the German Lloyds line from Bremen to Baltimore, and thence by the Baltimore and Ohio Railroad, and placed in the new National Museum Building. The exhibition will be more fully discussed in a report now being prepared, which in accordance with the resolutions of Congress will also treat of the present condition of the fisheries and fish-culture of Europe.

Respectfully submitted.
SPENCER F. BAIRD,
Secretary of Smithsonian Institution.

WASHINGTON, D. C., *January*, 1881.

APPENDIX TO THE REPORT OF THE SECRETARY.

STATISTICS OF EXCHANGES, 1880.

I.—FOREIGN EXCHANGE.

BOXES AND PARCELS RECEIVED IN 1880.

	Boxes.	Parcels.
I.—For home distribution:		
From Argentine Confederation	7	....
From Belgium	7	....
From Chile	3	....
From England	34	....
From England, for Library of Congress	13	....
From France	5	....
From Germany	27	....
From Holland	13	....
From Italy	1	....
From Mexico	2	....
From Russia	3	....
Total	115	6,670
II.—For distribution abroad:		
a. From government departments:	*Parcels.*	
Agricultural Department	1	....
Bureau of Ethnology	13	....
Chief Signal Office	201	....
Coast Survey	10	....
Engineer Bureau	105	....
Geological Survey (Wheeler)	851	....
Geological Survey (Powell)	110	....
Interior Department	861	....
Naval Observatory	783	....
Ordnance Department	133	....
Smithsonian Institution (Fish Commission and National Museum included)	3,156	....
Surgeon-General's Office	3	....
	5,227	....
b. From miscellaneous institutions and individuals	8,948	....
		14,175
Total, of which 71 contain specimens of natural history	....	20,845

BOXES SENT ABROAD IN 1880.

Country.	Number of boxes.	Country.	Number of boxes.
Argentine Confederation	3	New Zealand	9
Belgium	8	Norway	3
Brazil	3	Polynesia	1
Chile	2	Portugal	5
Cuba	3	Queensland	4
Denmark	7	Russia	12
France	24	Samoa	1
Germany	49	South Australia	1
Great Britain	51	Spain	3
Holland	10	Sweden	9
Italy	4	Switzerland	6
Japan	3	Tasmania	1
Liberia	1	Victoria	3
Mexico	5		
New South Wales	2	Total	233

Representing, in bulk, 1,631 cubic feet and weighing 52,425 pounds.
Besides the above, there are 13 boxes ready for and awaiting orders for shipment to Italy.
Exchanges for Canada are included in the report on domestic exchanges.

SHIPPING AGENTS OF SMITHSONIAN EXCHANGES.

Countries.	Agents.
Argentine Confederation	Carlos Caranza (& Co.), consul for the Confederation in New York.
Belgium	White Cross Line of Steamers of Antwerp (Funch, Edye & Co., agents), New York.
Bolivia	Joseph S. Spinney, New York.
Brazil	Charles Mackall, vice-consul, Baltimore. Merchants' Line of Steamers, New York.
Chile	D. DeCastro, consul, New York.
Costa Rica	Pacific Mail Steamship Company, New York.
Cuba	Consul-general for Spain, New York.
Denmark	Henrick Braem, consul for Denmark, New York.
Dutch Guiana	Thomas E. Bixby & Co., Boston.
Ecuador	A. Flores, New York.
Egypt	S. L. Merchant & Co., New York.
Finland	Abo, Wyburg, Wasa and Finland Steam Navigation Company of Hull; and Massey & Sawyer, Hull.
France	Compagnie Générale Transatlantique (L. de Bébian, agent), New York.
Germany	North German Lloyd (Oelrichs & Co., of New York; Schumacher & Co., of Baltimore). Hamburg-American Packet Company (Kunhardt & Co.), New York.
Great Britain	British and North American Royal Mail Steamship Company (Vernon H. Brown & Co., agents), New York. Baltimore and Ohio Railroad foreign freight department, Baltimore.
Greece	D. W. Botassi, consul for Greece, New York.
Guatemala	Jacob Baez, consul for Guatemala, New York.
Hayti	Atlas Steamship Company (Pim, Forwood & Co., agents), New York.
Italy	Anchor Steamship Line (Henderson & Bro., agents), New York.
Jamaica	Steamship lines for Brazil, Texas, Florida, and Nassau, New Providence (C. W. Mallory & Co., agents), New York.
Japan	Kentaro Yanagiyo, consul for Japan, San Francisco.
Liberia	American Colonization Society.
Mexico	Juan N. Navarro, consul for Mexico, New York.
Netherlands	Netherland-American Steam Navigation Company (H. Cazaux, agent) New York.
New South Wales	R. W. Cameron & Co., New York.
New Zealand	R. W. Cameron & Co., New York.
Norway	Christian Bórs, consul for Sweden and Norway, New York.
Peru	Joseph S. Spinney, New York.
Philippine Islands	Spanish consul, San Francisco.
Polynesia	Mr. Severance, consul for Polynesia, San Francisco.
Portugal	Gustav Amsink, consul for Portugal, New York.
Queensland	Baltimore and Ohio Railroad foreign freight department, Baltimore. Queensland department (Hon. A. McAllister), London.
Russia	W. Webtsky, consul-general, New York.
South Australia	R. W. Cameron & Co., New York.
Spain	Consul-general for Spain, New York.
Sweden	Christian Bórs, consul for Sweden and Norway, New York.
Switzerland	North German Lloyd (Schumacher & Co.), Baltimore, and Consul von Heyman, Bremen, Germany.
Syria	M. J. Chrysoveloni & Co., Liverpool, England.
Turkey	Turkish Legation, Washington.
Tasmania	Baltimore and Ohio Railroad foreign freight department, Baltimore, and Crown agents for the colonies, London, England.
Uruguay	William H. T. Hughes, general consul for Uruguay, New York.
Venezuela	Dallett, Boulton & Co., New York.
Victoria	R. W. Cameron & Co., New York.
West Indies	Thomas Donnison, New York (for Antigua); C. W. Mallory & Co., New York (for San Domingo); Wilson & Asmus, New York (for Turks Islands); Thomas Bland, New York; H. B. Bailey & Co., New York.

AGENCIES FOR THE DISTRIBUTION OF SMITHSONIAN EXCHANGES.

Countries.	Agencies.
AFRICA.	
Algeria	Commission Française des Échanges Internationaux, Paris, France.
Cape Colonies	William Wesley, London, England.
Egypt	Institut Égyptien, Alexandria, Egypt.
Liberia	College of Liberia, Monrovia.
Mauritius	William Wesley, London, England.
St. Helena	William Wesley, London, England.
AMERICA.	
British America	Geological Survey Office, Montreal, Canada.
Central America	Capt. J. M. Dow, general agent.
Costa Rica	University of Costa Rica, San José
Guatemala	Sociedad Economica de Amigos del Pais, Guatemala.
Mexico	El Museo Nacional, Mexico.
West Indies:	
Bahamas	Nassau Public Library, New Providence.
Barbadoes	Government Meteorological Office, Bridgeton.
Cuba	Royal University, Havana.
Jamaica	Royal Society of Arts, Kingston.
Trinidad	Scientific Association, Port-of-Spain.
Turks Island	Public Library of Grand Turk Island.
South America:	
Argentine Republic	Museo Publico, Buenos Ayres.
Bolivia	University, Chuquisaca.
Brazil	Commissão Central Brazileira de Permutações Internacionaes, Rio Janeiro.
Chile	Universidad, Santiago.
Colombia	Sociedad de Naturalistas Colombianos, Bogota.
Dutch Guiana	Surinaamsche Koloniaale Bibliotheek, Paramaribo.
Ecuador	Observatorio del Colegio Nacional, Quito.
Peru	Biblioteca Nacional, Lima.
Uruguay	Bureau de Statistique, Montevideo.
Venezuela	Sociedad de Ciencias Fisicas y Naturales, Caracas.
ASIA.	
China	William Wesley, London, England.
India	William Wesley, London, England.
Japan	Imperial University, Tokio.
Java	Bataav'sche Genootschap van Kunsten en Wetenschappen, Batavia.
Philippine Islands	Royal Economical Society, Manila.
AUSTRALASIA.	
New South Wales	Royal Society of New South Wales, Sydney.
Queensland	Government Meteorological Observatory, Brisbane.
South Australia	Astronomical Observatory, Adelaide.
Victoria	Public Library, Melbourne.
New Zealand	Parliamentary Library, Wellington.
Tasmania	Royal Society of Tasmania, Hobartown.
EUROPE.	
Austria-Hungary	Dr. Felix Flügel, Leipzig.
Belgium	Commission Belge d'Échanges Internationaux, Brussels.
Denmark	Kong. Danske Videnskabs Selskab, Copenhagen.
France	Commission Française des Échanges Internationaux, Paris.
Germany	Dr. Felix Flügel, Leipzig.
Great Britain	William Wesley, London.
Greece	National Library of Greece, Athens.
Iceland	K. Danske Videnskabs Selskab, Copenhagen.
Italy	Ulrico Hoepli, Milano.
Netherlands	Bureau Scientifique, Harlem.
Norway	Kongliga Norske Frederiks Universitet, Christiania.
Portugal	Escola Polytechnica, Lisbon.
Russia	L. Watkins & Co., St. Petersburg.
Spain	R. Academia de Ciencias, Madrid.
Sweden	Kongelige Svenska Vetenskaps Akademien, Stockholm.
Switzerland	Eidgenössensche Bundes Kanzlei, Bern.
Turkey	Legation, Washington, D. C.
POLYNESIA.	
Sandwich Islands	Royal Hawaiian Agricultural Society, Honolulu.

FOREIGN INSTITUTIONS IN CORRESPONDENCE WITH THE SMITHSONIAN INSTITUTION, DECEMBER 31, 1880.

Algeria	6
Argentine Confederation	17
Australia and Tasmania	47
Austria-Hungary	145
Belgium	119
Bolivia	1
Brazil	11
British America	21
British Guiana	3
Cape Colonies and St. Helena	7
Central America	2
Chile	10
China	7
Colombia	3
Denmark	31
Dutch Guiana	1
Ecuador	1
Egypt	8
France	365
Germany	576
Great Britain and Ireland	422
Greece	10
Holland	76
Iceland	14
India	36
Italy	198
Japan	8
Java	6
Liberia	2
Mauritius	4
Mexico	18
New Zealand	17
Norway	30
Paraguay	1
Peru	4
Philippine Islands	3
Portugal	37
Russia	166
Sandwich Islands	2
Spain	26
Sweden	24
Switzerland	78
Turkey	13
Uruguay	5
Venezuela	2
West Indies	12
International societies	7
Total	2,602

II.—DOMESTIC EXCHANGES.

LIST OF PACKAGES RECEIVED BY THE SMITHSONIAN INSTITUTION FROM EUROPE, AND DISTRIBUTED TO THE FOLLOWING NAMED INSTITUTIONS AND INDIVIDUALS IN THE UNITED STATES AND BRITISH AMERICA.

UNITED STATES.

Recipients.	Packages.
ALABAMA.	
Tuscaloosa:	
Geological Survey of Alabama	2
ARKANSAS.	
Holly Grove:	
Literary Institute	1
Little Rock:	
Governor of the State	2
CALIFORNIA.	
Oakland:	
University	2
Sacramento:	
Agricultural and Horticultural Society	1
State Agricultural Society	6
State Library	1
San Francisco:	
Academy of Science	91
California Historical Society	1
Governor of the State	2
Mercantile Library Association	1
Microscopical Society	1
COLORADO.	
Denver:	
Governor of the State	1
CONNECTICUT.	
Hartford:	
American Philological Association	1
Library, Young Men's Institute	1
Murphy Philosophical Association	1
State Agricultural Society	1
Watkinson and Connecticut Historical Society	1
Watkinson Reference Library	1
Middletown:	
Wesleyan University	2
CONNECTICUT—Continued.	
New Haven:	
American Oriental Society	24
American Journal of Arts and Sciences	44
Connecticut Academy of Sciences	111
Observatory of Yale College	2
Peabody Museum	1
Sheffield Scientific School	6
Yale College	18
DISTRICT OF COLUMBIA.	
Georgetown:	
College	1
Observatory	3
Washington:	
Agricultural Department	118
Anthropological Society	2
Army Medical Museum	7
Belgian Legation	1
Board of Health	3
Bureau of Construction and Repair	1
Census Bureau	8
Chinese Legation	1
Chief Signal Office	29
Coast Survey	58
Columbian University	2
Cosmos Club	1
Education, Bureau of	19
Engineer Bureau U. S. A	27
Entomological Commission	3
Fish Commission	4
General Land Office	6
Geological Survey of the Territories	68
Hydrographic Office	9
Indian Bureau	3
Indian Commissioners	4
Interior Department	9
Institution for the Deaf and Dumb	1
Library of Congress	44
Light House Board	2
Marine Hospital	2
Medical Association	44
Medicine and Surgery, Bureau of	1

List of packages received by the Smithsonian Institution, &c.—Continued.

UNITED STATES—Continued.

Recipients.	Packages.
DISTRICT OF COLUMBIA—Continued.	
Mint Bureau	3
National Academy of Sciences	111
National Museum	5
Nautical Almanac	15
Naval Observatory	88
Navigation, Bureau of	7
Navy Department	2
Ordnance Department	3
Patent Office	58
Provost-Marshal-General's Office	1
State Department	4
Statistics, Bureau of	23
Surgeon-General's Office	95
Treasury Department	7
War Department	9
GEORGIA.	
Atlanta:	
City Library	1
Augusta:	
Medical College	1
Savannah:	
Georgia Historical Society	1
ILLINOIS.	
Bloomington:	
Museum of Natural History	3
Carbondale:	
Southern Illinois Normal University	1
Chicago:	
Academy of Sciences	77
Astronomical Society	1
Dearborn Observatory	2
Free Library	1
Observatory	3
Public Library	4
Rush Medical College	1
State Microscopical Society	2
University	1
Normal:	
Illinois Museum of Natural History	5
Ottawa:	
Academy of Natural Science	1
Springfield:	
State Library	1
Rock Island:	
Augustana College	1
INDIANA.	
Indianapolis:	
Academy of Sciences	1
Bureau of Statistics and Geology	2
Geological Survey of Indiana	7
Owen Cabinet	1
IOWA.	
Davenport:	
Academy of Sciences	53
Des Moines:	
Analyst	1
Governor of Iowa	5
State Library	1
State University	3
Dubuque:	
Iowa Institute of Science and Arts	1
Iowa City:	
Iowa Weather Service	3
University of Iowa	12
KANSAS.	
Lawrence:	
Academy of Science	1
Topeka:	
Academy of Science	7
Kansas Historical Society	3

Recipients.	Packages.
KENTUCKY.	
Frankfort:	
Geological Survey of Kentucky	3
Lexington:	
Transylvania Medical College	1
Louisville:	
Medical Department, University of Louisville	1
Public Library	1
LOUISIANA.	
Baton Rouge:	
State University	1
New Orleans:	
Academy of Science	53
L'Athénée	1
Medical Department, University of Louisiana	1
State Library	1
MAINE.	
Augusta:	
Commissioner of State	1
Natural History and Geological Society	1
Brunswick:	
Bowdoin College	3
Historical Society	2
Portland:	
Society of Natural History	15
Waterville:	
Colby University	1
MARYLAND.	
Annapolis:	
United States Naval Academy	5
Baltimore:	
Academy of Sciences	2
American Journal of Chemistry	1
American Journal of Mathematics	3
Historical Society	3
Johns Hopkins University	14
Maryland Institute	2
Peabody Institute	34
MASSACHUSETTS.	
Amherst:	
Amherst College	2
Boston:	
American Academy of Arts and Sciences	151
American Gynecological Society	2
American Naturalist	3
American Social Science Association	1
American Statistical Association	7
Athenæum	4
Boston Hospital	1
Boston Public Library	16
Boston Scientific Society	1
Boston Society of Natural History	179
Bowditch Library	4
Commonwealth of Massachusetts	3
Christian Register	1
City Library	1
Entomological Club "Psyche"	1
Massachusetts Historical and Genealogical Society	3
Massachusetts Institute of Technology	2
Mayor of the city	1
Medical and Surgical Journal	10
New England Historic and Genealogical Society	3
Prison Discipline Society	1
Public Free Library	1
State Board of Agriculture	1
State Board of Charities	1
State Board of Health	12
State Library	8

List of packages received by the Smithsonian Institution, &c.—Continued.

UNITED STATES—Continued.

Recipients.	Packages.
MASSACHUSETTS—Continued.	
Cambridge:	
Botanical Museum	1
Entomological Club	2
Harvard College	37
Harvard College Observatory	20
Lawrence Scientific School	1
Museum of Comparative Zoölogy	88
Nuttall Ornithological Club	1
Peabody Museum	8
Jamaica Plain:	
Bussey Institution	5
Salem:	
American Association for the Advancement of Science	42
American Naturalist	2
American Oriental Society	7
Essex Institute	71
Peabody Academy	75
Williamstown:	
Astronomical Observatory	1
Worcester:	
American Antiquarian Society	8
MICHIGAN.	
Ann Arbor:	
Geological Survey of Michigan	1
Observatory	7
Society of Agriculture	1
University	1
Coldwater:	
Michigan Library Association	2
Detroit:	
Geological Survey of Michigan	1
State Agricultural Society	3
Lansing:	
State Board of Health	17
State Library	1
MINNESOTA.	
Minneapolis:	
Academy of Sciences	3
University	1
Saint Paul:	
Chamber of Commerce	1
Historical Society of Minnesota	1
MISSOURI.	
Glasgow:	
Morrison Observatory	1
Jefferson:	
State Board of Agriculture	1
Kansas City:	
Kansas Review of Science, Arts, and Industry	1
Rolla:	
Geological Survey of Missouri	8
School of Mines	1
Saint Louis:	
Academy of Science	132
Mercantile Library	2
Peabody Academy	2
Public Library	1
Public School Library	6
State Board of Agriculture	2
Washington University	1
NEW HAMPSHIRE.	
Concord:	
New Hampshire Historical Society	2
Hanover:	
Dartmouth College	5
Observatory	4
NEW JERSEY.	
Hoboken:	
Stevens Institute of Technology	4
Newark:	
New Jersey Historical Society	1
New Brunswick:	
Geological Society of New Jersey	5
Rutgers School	1
Princeton:	
Green School of Science	1
College of New Jersey	7
Observatory	4
NEW YORK.	
Albany:	
Adirondack Survey Office	3
Albany Institute	6
Dudley Observatory	17
Insurance Department	1
New York Medical Society	1
Secretary of State	2
State Agricultural Society	18
State Cabinet of Natural History	3
State Library	47
State Museum of Natural History	3
University	8
Brooklyn:	
Brooklyn Library	1
Entomological Society	3
Mercantile Library	1
Buffalo:	
Buffalo Historical Society	2
Buffalo Practical School	1
Buffalo Society of Natural Sciences	45
Clinton:	
Litchfield Observatory of Hamilton College	4
Ithaca:	
Cornell University	2
New York City:	
Academy of Medicine	3
Academy of Science	95
American Agriculturist	1
American Chemical Society	8
American Chemist	4
American Ethnological Society	4
American Geographical Society	75
American Institute	7
American Institute of Architects	4
American Journal of Chemistry	1
American Journal of Microscopy	1
American Society of Civil Engineers	5
Astor Library	16
Chamber of Commerce	1
College of Physicians and Surgeons	1
Columbia College	1
Cooper Union	1
Engineering and Mining Journal	8
Lenox Library	1
Manufacturer and Builder	8
Mayor of the City	1
Mercantile Library Association	3
Meteorological Observatory	2
Metropolitan Museum of Arts	3
Museum of Natural History	8
New York Historical Society	3
New York Medical Journal	2
New York Microscopical Society	1
New York Sanitary Commission	4
New York Society Library	1
New York Society of Libraries	1
New York Times	2
Observatory Central Park	5
Public Health Association	1
Sanitarian	9
School of Mines	11
Scientific American	1

List of packages received by the Smithsonian Institution, &c.—Continued.

UNITED STATES—Continued.

Recipients.	Packages.
New York—Continued.	
Van Nostrand's Magazine	1
University	2
Poughkeepsie:	
Society of Natural Sciences	3
Vassar College	2
Schenectady:	
Union College	1
Troy:	
Rensselaer Polytechnic Institute	1
West Point:	
United States Military Academy	4
NORTH CAROLINA.	
Raleigh:	
State Library	1
OHIO.	
Ashtabula:	
Anthropological Society	3
Cincinnati:	
Astronomical Society	1
Cincinnati University	2
Geological Society	1
Medical College of Ohio	1
Mercantile Library	1
Observatory	22
Public Library	2
Society of Natural History	11
Cleveland:	
Kirtland Society	1
Columbus:	
Geological Survey	3
State Board of Agriculture	35
State Library	1
Gambier:	
Kenyon College	1
Oberlin:	
Oberlin College	1
Urbana:	
Central Ohio Scientific Association	4
Yellow Spring:	
Antioch College	1
PENNSYLVANIA.	
Allegheny:	
Allegheny Observatory	5
Bethlehem:	
Lehigh University	2
Easton:	
Institution of Mining Engineers	6
Pardee Science School	1
Harrisburg:	
Second Geological Survey	1
State Library	2
Philadelphia:	
Academy of Fine Arts	1
Academy of Natural Sciences	197
American Entomological Society	24
American Journal of Conchology	3
American Naturalist	7
American Pharmaceutical Association	15
American Philosophical Society	108
Board of State Charities	1
Board of Trade	3
Central High School	1
Franklin Institute	28
Geological Society	1
Geological Survey of Pennsylvania	2
Historical Society	6
Pennsylvania—Continued.	
Library Company	2
Library of Pennsylvania Hospital	2
Medical Times	9
Mercantile Library	2
Observatory Girard College	3
Pennsylvania House of Refuge	1
Polytechnic Bulletin	1
University of Pennsylvania	2
Wagner Free Institute	6
Zoological Garden	2
Zoological Society	14
Pittsburg:	
Mercantile Library	1
RHODE ISLAND.	
Providence:	
American Naturalist	2
Athenæum	1
Brown University	3
Rhode Island Historical Society	3
SOUTH CAROLINA.	
Charleston:	
College of Charleston	1
Elliot Society of Natural History	13
Library Society	1
Library, University of Charleston	1
Medical School of South Carolina	1
Society Library	1
Columbia:	
South Carolina College Library	1
University	1
TENNESSEE.	
Nashville:	
State Library	1
TEXAS.	
Chapel Hill:	
Soulé University	2
VERMONT.	
Burlington:	
University of Vermont	3
Castleton:	
Orleans County Society of Natural Sciences	13
VIRGINIA.	
Charlotteville:	
University of Virginia	7
Hampton:	
Library of Hampton College	1
Lexington:	
School of Engineers	1
Virginia Military Institute	2
Richmond:	
Medical College	1
State Library	2
WISCONSIN.	
Madison:	
State Agricultural Society	10
State Historical Society	4
Wisconsin Academy	27
Wisconsin University	1
Milwaukee:	
Natural History Society	18

List of packages received by the Smithsonian Institution, &c.—Continued.

BRITISH AMERICA.

Recipients.	Packages.
CANADA.	
Hamilton, Ontario:	
Scientific Association	2
Kingston, Ontario:	
Botanical Society of Canada	1
Montreal, Quebec:	
Canadian Medical Record	1
Canadian Medical and Surgical Journal	1
Canadian Naturalist	7
Geographical Society	1
Geological Survey of Canada	15
Government of Canada	1
L'Union Médicale de Canada	1
Medical Association of Canada	1
Natural History Society	20
Société d'Agriculture du Bas-Canada	1
Ottawa, Ontario:	
Academy of Natural Sciences	1
Library of Parliament	8
Quebec, Quebec:	
Geographical Society	2
Historical Society	1
Historical and Natural History Society	2
Laval University Library	1
Literary and Historical Society	4
Literary and Philosophical Society	3
Naturaliste Canadien	6
Toronto, Ontario:	
Canadian Entomologist	1
CANADA—Continued.	
Canadian Institute	25
Canadian Journal of Medical Science	4
Canadian Naturalist	1
Entomological Society	2
Geological Survey Office	1
Literary and Historical Society	1
Magnetic Observatory	5
Meteorological Office	8
Public Library	1
University	1
University College	1
NEW BRUNSWICK.	
Fredericton:	
University of New Brunswick	1
Saint John:	
Natural History Society	1
NEWFOUNDLAND.	
Saint Johns:	
Geological Survey of Newfoundland	6
Legislative Library	1
NOVA SCOTIA.	
Halifax:	
Nova Scotian Institute of Natural Sciences	13

INDIVIDUALS.

Names.	Packages.
Abbe, Prof. C	13
Abbot, C. C	1
Abbot, S. L	1
Abbott, Gen, F. L	1
Abert, Col. S. T	1
Adams, Charles F	2
Agassiz, Prof. A	8
Aldis, Judge A. O	1
Alexander, Prof. Stephen	2
Alvord, Gen. B	3
Anderson, Alex. C	1
Andrews, R. R	2
Angell, James B	2
Antisell, Dr. Thomas	1
Appleton & Co	2
Apthorp, Robert E	2
Ashburner, Charles A	2
Ashe, Commander E. D	2
Atkinson, W. B	1
Avery, R. S	1
Babcock, Gen. O. E	1
Bache, L	1
Bache, Professor	1
Baird, Prof. S. F	31
Baker, Henry B	1
Ballard, Joshua	1
Bancroft, Hon. George	3
Barclay, James F	1
Barfoot, Professor	1
Barker, Prof. George F	2
Barlow, Hon. Francis	2
Barlow, Scott	1
Barnard, Rev. Dr	2
Barnard, James M	2
Barnes, General	1
Barnes, Hon W	4
Barnston, George	1
Bates, F. H	1
Bausett, S. P	1
Beardslee, Commander	1
Beecher, C. E	2
Belfrage, G. W	1
Bell, Robert	1
Bellows, Rev. F. W	2
Berkmans, Mr	8
Bessels, Dr. E	20
Bethune, Rev. C. J. S	1
Bickmore, Prof. A. L	3
Bien, Julius	2
Bigelow, Frank H	2
Billings, Dr. J. S	3
Birney, General W	1
Blackman, Charles S	1
Blake, Prof. W. P	2
Bland, Thomas	1
Blasius, W	6
Bleasdell, Rev. William	1
Boutcher, C. S	1
Boyden, U. N	2
Bransford, Dr. J. F	3
Brendel, Dr. Fred	1
Broadhead, G. C	2
Brooke, Maj. T. B	2
Brown, Horace	1
Brush, Prof. George I	8
Burgess, Ed	1
Burnham, S. W	7
Burnett, Dr. S. M	2
Butler, Charles E	2
Butler, James D	1
Cameron, Allan	1
Carll, John C	2
Capron, Hon. Horace	1
Carman, Hon. E. A	1

List of packages received by the Smithsonian Institution, &c.—Continued.

INDIVIDUALS—Continued.

Names.	Packages.
Carr, Luc	1
Case, Leonard	2
Casey, Colonel	1
Chamberlain, Dr. C. W	1
Chambers, Prof. V. T	1
Chance, H. M	1
Chandler, Prof. Charles F	2
Chandler, S. C., jr	2
Chapman, Dr. C	2
Chickering, Prof. J. W	1
Clark, Ed	1
Coffin, Prof. J. H. C	4
Comstock, Gen. C. B	1
Comstock, Prof. J. H	2
Conn, Dr. G. T	1
Cook, Prof. George H	4
Cook, Prof. J. P	1
Cope, Professor	9
Coppee, Prof. H	2
Corson, Prof. Hiram	1
Coues, Dr. Elliott	10
Coxe, E. B	1
Cox, Prof. E. T	1
Crosby, Joseph	1
Crosby, W. O	2
Crunden, F. M	1
Cutts, Col. R. D	2
Dall, W. H	12
Dana, Prof. E. S	2
Dana, Prof. J. D	34
Dana, Richard H	2
Darrach, Dr. James	1
Davis, H. C	1
Davis, Lieut. Com. C. H	1
Davis, Mr	2
Davis, Rear-Admiral	2
Davis, William M	2
Davidson, Prof. George	3
Dawson Bros	1
Dawson, George M	3
Dawson, J. W	2
Dawson, Principal	1
Dean, John Ward	1
Dowey, Melvil	1
Dike, Camden	1
Dinwiddie, R	1
Dobson, James	1
Dobson, John	1
Dodge, A. G. Phelps	1
Dolley, Dr. S. R. A	1
Doolittle, M. H	1
Douglas, Fred	1
Dow, Capt. J. M	7
Dow, Hon. Neal	1
Downes, John	2
Draper, Dr. Daniel	1
Draper, Dr. H	1
Draper, L. C	1
Dufrasne, Abbé	1
Dutton, Captain	3
Eastman, Prof. J. R	2
Eaton, Hon. John	2
Eaton, William S	2
Edwards, H	1
Egleston, Professor	1
Elliot, Dav. Giraud	2
Elliott, E. B	1
Elliott, Samuel	1
Ellis, J. B	3
Ellis, Rev. George E	2
Emerson, Prof. G. B	5
Emmons, S. F	1
Endlich, Dr. F. M	5
Engelman, Dr. George	4
Ericson, Captain	1
Evans, John D	1
Everett, Percival L	2
Ewart, John G	1
Fairey, Richard	1
Farlow, Prof. W. G	3
Farquhar, E. J	2
Farquharson, Dr. R. I	2
Ferrel, Prof. W	5
Field, D. Dudley	1
Fields, James F	2
Fisher, Dr. G. J	2
Fiss, George W	1
Flag, Samuel	1
Flagg, M. C	1
Fletcher, Dr. R	2
Flint, W	2
Flügel, Hermann	1
Fontaine, Professor	3
Forbes, Dr. R. W	1
Fortin, Dr. Pierre	1
Fowler, Rev. James	1
Frazer, Persifor	2
Fristoe, Prof. E. T	2
Frisby, Prof. E	2
Frothingham, Mr	1
Fuller, H. W	2
Furness, H. H	1
Gale, Dr. L. D	2
Gallaudet, Dr. E. M	2
Galt, Sir A. J	1
Gamgee, Professor	1
Gannett, Henry	3
Gannett, Rev. W. C	1
Gant, James A	1
Gardner, Hon. W. S	2
Garnett, Dr. A. G. P	1
Garnett, Dr. S. G. P	1
Gatschet, Albert	2
Genth, Dr. F. A	1
Gibbs, Philip H	1
Gibbs, Prof. L. R	2
Gibbs, Prof. Wolcott	3
Gilbert, G. K	6
Gill, Dr. T. N	5
Gilpin, Bernard	1
Goodall, A. G	2
Goode, G. Brown	9
Goodfellow, Ed	5
Graves, Doctor	1
Gray, Prof. Asa	15
Gray, Hon. Horace	2
Green, B. R	1
Green, Prof. S. S	1
Greene, Lieut. F. V	3
Greene, Mrs. B. D	2
Grew, Henry S	2
Guyot, Professor	10
Hagen, Prof. H. A	10
Haines, Col. P. C	2
Hale, Hon. George S	2
Hall, Prof. A	6
Hall, Prof. C. E	2
Hall, Prof. James	19
Hambach, Dr. G	3
Hammond, Dr. W. A	1
Hanks, I	2
Hanson, P	1
Harding, C. L	2
Harding, Edgar	1
Harding, George W	1
Harkness, Professor	4
Harrington, Dr. B. J	2
Harris, Clarendon	2
Harvey, L. F	1
Hathaway, C. L	2
Hawley, H. Q	2
Hayden, D. H	1
Hayden, Prof. F. V	131
Heatherington, A. H	1
Hedrick, Prof. B. S	2
Hedrick, John T	2

List of packages received by the Smithsonian Institution, &c.—Continued.

INDIVIDUALS—Continued.

Names.	Packages.	Names.	Packages.
Henry, James	1	Lyman, Professor	5
Henry, Mrs	1	Macfarlane, R. M	1
Hess, Miss Sallie A	1	Macoun, Prof. John	1
Higgins, E. S	1	Maisch, John M	1
Hildebrand, E	1	Mallery, Colonel	2
Hilgard, Prof. J. E	10	Mallett, Prof. J. W	1
Hill, George W	6	Mann, Mrs. Horace	2
Hind, Prof. H. Y	1	Mannigault, G. E	5
Hinde, George J	1	Marcou, Prof. Jules	7
Hinrichs, Prof. G	11	Marcou, Phil. B	1
Hitchcock, Professor	4	Marcy, Prof. Oliver	1
Hoffmann, Dr. W. J	1	Marsh, Prof. O. C	8
Holden, Prof. E. S	7	Martin, H. N	1
Holmes, N	1	Marvin, J. B	2
Holmes, Dr. O. W	2	Mason, Prof. O. T	2
Holmes, W. H	2	Matthews, G. F	1
Holtzer, Charles W	1	Mayer, Prof. Alf. M	2
Horn, M	1	McCagg, Ezra B	2
Horn, G. A	1	McChesney, Joseph	1
Hough, Frank B	2	McCreath, A. S	2
How, Prof. H	1	McGee, W. J	5
Howell, Prof. E. E	1	McGuire, F. B	1
Howgate, Capt. H. W	4	McLaughlin, W. R	1
Huart, Abbé Victor	3	McLennan, K	1
Hudson, B	1	Meigs, Dr. Aitken	1
Humphreys, General A. A	4	Meigs, General M. C	2
Hunt, Charles O	1	Miller, S. A	11
Hunt, Prof. J. Henry	8	Mohr, Paul	2
Hyatt, Prof. A	2	Morong, Rev. Thomas	1
Jackson, A. W., jr	1	Morse, Prof. Dr	8
James, Prof. W	1	Morton, President H	2
Janes, Rev. Owen	1	Mosely, Edward S	2
Jarvais, Dr. Ed	13	Mosman, Alonzo F	2
Jelliffe, Samuel G	1	Moulding, Thomas	1
Jenkins, Admiral	1	Murray, William	1
Johnson, A. B	1	Myer, General A. J	14
Johnston, Dr. W. W	2	Nagle, Dr. John T	1
Jones, C. C	1	Newberry, Dr. I. S	3
Jones, J. Matthew	2	Newcomb Prof. S	17
Joy, Prof. Charles A	2	Newton, H	1
Kendall, Prof. E. O	2	Newton, Prof. H. A	4
Kerr, Prof. W. C	1	Nicholson, W. H	1
Kidder, Dr. J. H	2	Nicholson, W. L	1
Kilbourne, Lieutenant	1	Nipher, Prof. F. E	4
Kimball, I. P	1	Nordhoff, C	1
King, Dr. A. F. A	2	Norris, J. Parker	1
King, Prof. Clarence	21	Nourse, Prof. J. E	4
Kingsley, W. L	1	Oliver, Dr. O. C	1
Kingston, G. T	2	Olmstead, Rev. L. G	1
Kirkwood, Prof. Dr. Daniel	1	Ordway, Dr. A	1
Knapp, Dr. James	8	Osborne, J. W	1
Knox, J. J	1	Otis, Dr. G. A	1
Laflamme, Prof. J. C. K	1	Otto, Rev. E	1
Laforme, J. A	1	Outerbridge & Co	1
Lane, George M	2	Packard, Prof. A. S., jr	5
Lane, W. C	2	Packard, Dr. John H	2
Langley, Prof. S. P	2	Packer, H. E	1
Lawrence, George N	3	Paine, Prof. Martin	1
Lawrence, H. D	1	Parke, General J. G	1
Lawrence, Hon. W. B	1	Parker, Dr. Peter	1
Lea, Dr. Isaac	20	Parkhurst, H. M	2
LeConte, Dr. John L	13	Parkman, Prof. Francis	2
Le Conte, Prof. John	2	Parry, Dr. C. C	2
Le Conte, Prof. Joseph	2	Patterson, Capt. C. P	2
Lee, Admiral S. P	1	Paul, F. M	1
Lee, Dr. William	7	Pearson, Jonathan	2
Lees, John S	1	Peck, Charles H	1
Leidy, Dr. Joseph	6	Peet, Rev. Stephen	4
Lesley, J. P	9	Peirce, Prof. B	1
Lesquereux, Leo	2	Peters Prof. C. H. F	3
L'Géncrantz, G. A. M	1	Peters, G. F	1
Lincoln, Dr. N. S	1	Phillips, Henry	1
Linden, Prof. Leopold	2	Pickering, Prof. Edward C	4
Livermore, Rev. Dr	1	Pickering, Henry	2
Lockwood, Prof. S	1	Pierce, Prof. B	5
Loomis, Prof. E	10	Poe, General O. M	1
Lovering, Prof. Joseph	2	Poesche, Theodore	1
Lowe, F. C	1	Poole, Herman	2

List of packages received by the Smithsonian Institution, &c.—Continued.

INDIVIDUALS—Continued.

Names.	Packages.	Names.	Packages.
Pourtales, Prof. L. M	8	Spencer, Prof. J. W	1
Powel, Samuel	3	Spofford, A. R	2
Powell, Prof. J. W	7	Stearns, R. E. C	1
Prentiss, Prof. D. W	3	Steeves, F. H	1
Prime, Fred	2	Stevens, Mr	1
Pringle, C. G	1	Stevenson, W. C	1
Pritchett, C. W	1	Stewart, Dr. James O	1
Prout, Dr. H. D	1	Stockwell, John N	3
Provancher, Abbé	1	Storer, Professor	2
Pumpelly, Ralph	1	Strecker, H	1
Putnam, F. W	2	Swallow, Prof. G. C	1
Putnam, J. Duncan	5	Sweet, E. G	1
Quincy, Miss E	2	Switt, L	2
Quincy, General S. M	2	Sylvester, Prof. J	1
Quincy, Hon. Josiah	2	Taft, R. C	1
Rau, Dr. Charles	6	Tanner, Lieut. Z. L	2
Redfield, Professor	2	Taylor, W. B	2
Ridgway, R	4	Thome, Dr. S. H	1
Riley, Prof. C. V	8	Thomson, J. H	6
Rising, Prof. W. B	1	Thurston, R. H	1
Ritter, W. F. McK	4	Tilton, Capt. McLane	2
Roberts, George	1	Todd, D. P	3
Robinson, R. W	1	Tolles, Robert B	2
Rock, Miles	2	Toner, Dr. J. M	3
Rodgers, Admiral John	2	Toomer, James H	2
Roebuck, Dr. P. J	1	Torrey, Prof. H. W	2
Roessler, Doctor	1	Trouvelot, L	1
Roessler, F. E	3	Troyer, C	1
Rogers, Prof. F	2	Tuckermann, Prof. Edw	6
Rogers, Prof. W. A	2	Turner, P. J	1
Rogers, Prof. W. B	1	Twining, Major	1
Rominger, Professor	1	Twining, Professor	2
Rood, Prof. O. N	2	Upton, Hon. J. K	1
Rowland, Prof. F. A	1	Vasey, Dr. George	3
Roy, Mrs. William	1	Venable, Prof. Charles S	2
Royer, C. C	1	Venning, W. H	1
Russell, Lindsey	1	Verrill, Prof. Dr	2
Rutherford, L. M	5	Von Name, Addison	1
Safford, Prof. James	5	Wachsmuth, Charles	2
Safford, Prof. T. H	1	Walker, General F. A	6
Salisbury, E. E	2	Ward, George Cabot	2
Salisbury, Prof. Stephens	7	Ward, Prof. H. A	1
Sanborn, S. Brooks	1	Ward, Lester F	2
Sands, Admiral	1	Ward, R. H	1
Sanford, John E	3	Warder, Dr. A	2
Saville, James H	2	Warren, General G. K	1
Schott, Dr. Charles A	5	Waterstown, Rev. R. C	6
Schneider, F	1	Watson, Prof. James C	3
Schrader, August	1	Watt, David A. P	1
Schurz, Hon. Carl	2	Webster, Prof. H. E	1
Schuster, M	2	Weeden, W. B	1
Scudder, Dr. S. H	8	Welling, Dr. J. C	2
Scudder, R. H	2	Werner, Prof. H	1
Searle, Arthur	2	Weston, H. C	1
Searle, Rev. G. M	2	Wheatley, Prof. C. M	2
Selwyn, A. R. C	0	Wheeler, Capt. G. M	20
Serjeant, Professor	1	Whipple, George M	1
Setchel, T. H	1	Whitcher, Hon. W. F	1
Shaler, Prof. N. S	5	White, Dr. C. A	1
Shepherd, Prof. H. E	1	White, Dr. Charles H	1
Sherman, General W. T	1	White, Prof. R. Grant	1
Sherman, Hon. John	1	Whitcares, J. F	1
Sherwood, Andrew	2	Whitmore, W. H	1
Sigsbee, L. D	1	Whitney, H. A	2
Sigsbee, L. P	1	Whitney, Prof. J. D	18
Silliman, Prof. B	8	Whitney, Prof. W. D	8
Simon, Dr. Wil	1	Whittier, John G	1
Slater, H. N., jr	1	Wigglesworth, Dr. E	2
Smith, Dr. George	1	Wigglesworth, Mrs. E	2
Smith, E. A	1	Wilder, Prof. B. G	2
Smith, Mrs. Alex	1	Willoy, Henry	1
Smith Prof. E	1	Williams, David	1
Smith, W. H	1	Williamson, Col. R. S	1
Smith, J. Q	1	Wilmot, Samuel	1
Smith, Prof. H. L	1	Wilson, Col. John M	1
Smith, Prof. J. L	1	Wilson, Hon. J. O	1
Smock, J. C	2	Willson, Robert W	2
Snow, Dr. E	4	Winchell, Prof. Alex	2

List of packages received by the Smithsonian Institution, &c.—Continued.

INDIVIDUALS—Continued.

Names.	Packages.	Names.	Packages.
Winchell, Prof. N. H	2	Worthen, Prof. A. H	4
Winslow, Erving	2	Wright, Prof. A	2
Winyor, Justin	1	Wright, Prof. A. W	1
Wolcott, C. D	4	Wyman, Prof. M	2
Wood, Prof. H. C	1	Young, Prof. C. A	6
Wood, William & Co	1	Young, Clarence B	2
Woodbury, Hon. C. L	2	Yarrow, Doctor	5
Woodward, Dr. J. J	6	Youmans, Dr. E. L	1
Woodworth, Dr. J. M	1	Zaremba, Dr. C. W	3

RECAPITULATION.

	Institutions.			Institutions.	
	Addresses.	Parcels.		Addresses.	Parcels.
Alabama	1	2	New Hampshire	3	11
Arkansas	2	3	New Jersey	7	23
California	9	106	New York	63	485
Colorado	1	1	North Carolina	1	1
Connecticut	14	314	Ohio	17	91
District of Columbia	45	910	Pennsylvania	32	459
Georgia	3	3	Rhode Island	4	9
Illinois	15	104	South Carolina	8	20
Indiana	4	11	Tennessee	1	1
Iowa	8	79	Texas	1	2
Kansas	3	11	Vermont	2	16
Kentucky	4	6	Virginia	6	14
Louisiana	5	57	Wisconsin	5	60
Maine	6	23	British America	38	148
Maryland	8	64			
Massachusetts	44	789	Total	385	4, 021
Michigan	9	34	Individuals	560	1, 566
Minnesota	4	6			
Missouri	12	158	Total	945	5, 587

III.—GOVERNMENT EXCHANGES.

	Parcels.	Parcels.
RECEIVED.		
120 sets (of 50 copies each) of publications for box "N"	6, 000	
184 sets for box O	9, 200	
		15, 200
DISTRIBUTED.		
a. To foreign governments:		
35 boxes "N," each containing 187 copies of documents	6, 545	
b. To Library of Congress:		
2 copies each of 304 sets of documents delivered by the Public Printer	608	
		7, 153

Box "N" of government exchanges was sent to the following-named governments:

Argentine Confederation.
Bavaria.
Belgium.
Brazil.
Buenos Ayres.
Canada.
Chile.
Denmark.
France (one for government, one for distribution among the departments).
Germany.
Great Britain.
Greece.
Hayti.
Japan.
Mexico.
Netherlands.
New South Wales.
New Zealand.
Norway.
Ontario (Canada).
Portugal.
Prussia.
Queensland.
Saxony.
Spain.
Sweden.
Switzerland.
South Australia.
Tasmania.
Turkey.
Venezuela.
Victoria.
Würtemberg.

England also received box M, withheld from last year's sending.
For the Government of Italy 13 boxes (A to N) are ready and awaiting orders for shipment.

ESTABLISHMENTS DESIGNATED FOR THE RECEPTION OF GOVERNMENT EXCHANGES.

Countries.	Establishments.
Argentine Confederation	Government, Buenos Ayres.
Belgium	Commission Belge d'Échanges Internationaux, Brussels.
Brazil	Government, Rio Janeiro.
Buenos Ayres	Government, Buenos Ayres.
Canada	Parliamentary Library, Ottawa.
Ontario	Legislative Library, Toronto.
Chile	Government, Santiago.
Denmark	Royal Library, Copenhagen.
France	Commission Française des Échanges Internationaux, Paris.
Germany	Reichstags Bibliothek, Berlin.
Bavaria	Royal Library, München.
Prussia	Royal Library, Berlin.
Saxony	Royal Library, Dresden.
Würtemberg	Royal Library, Stuttgart.
Great Britain	British Museum, London.
Greece	Government, Athens.
Hayti	Sécrétaire d'État des Relations Extérieures, Port-au-Prince.
Japan	Ministère des Affaires Étrangères, Tokio.
Mexico	Government, Mexico.
Netherlands	Royal Library, The Hague.
New South Wales	Royal Society of New South Wales, Sydney.
New Zealand	Parliamentary Library, Wellington.
Norway	K. Norske Fredericks Universitet, Christiania.
Portugal	Government, Lisbon.
Queensland	Government, Brisbane.
Spain	Government, Madrid.
Sweden	Government, Stockholm.
Switzerland	Bundes Kanzlei, Bern.
South Australia	Government, Adelaide.
Tasmania	Parliamentary Library, Hobarton.
Turkey	Government, Constantinople.
Venezuela	Government, Caracas.
Victoria	Public Library, Melbourne.

RECAPITULATION.

	Parcels.	Parcels.
RECEIVED.		
1. For home distribution	6,670	
2. For distribution abroad	14,175	
3. For government exchange	15,200	36,045
DISTRIBUTED.		
1. Smithsonian exchanges:		
To establishments abroad, 233 boxes	10,384	
To home institutions and individuals	5,587	
2. Government exchanges:		
To governments abroad, 35 boxes (N), containing 187 documents each	6,545	
To Library of Congress, 2 copies each of 304 sets of documents	608	23,124

LIST OF PERIODICALS RECEIVED BY THE SMITHSONIAN INSTITUTION.

The following is a list of the Periodicals received by the Smithsonian Institution (exclusive of the Transactions of learned Societies), a large portion of them being presented by the publishers in exchange for the Annual Reports or other publications:

Aborigines' Friend. London, England. Ir.
Academy. London, England. Weekly.
Aéronaute. Paris, France. Monthly.
Allgemeine Bibliographie. Leipsic, Saxony. Monthly.
American Architect and Building News. Boston, Mass. Weekly.
American Bookseller. New York, N. Y. Weekly.
American Chemical Journal. Baltimore, Md. Monthly.
American Gas Light Journal. New York, N. Y. Semi-monthly.
American Journal of Insanity. Utica, N. Y. Quarterly.
American Journal of Mathematics, Pure and Applied. Baltimore, Md. Quarterly.
American Journal of Otology. New York. Quarterly.
American Journal of Pharmacy. Philadelphia, Pa. Monthly.
American Journal of Science. New Haven, Conn. Monthly.
American Manufacturer and Iron World. Pittsburgh and Philadelphia, Pa. Weekly.
American Monthly Microscopical Journal. New York, N. Y. Monthly.
American Naturalist. Philadelphia, Pa. Monthly.
Anales de la Asociacion Larrey. Mexico. Ir.
Anales de la Real Academia de Ciencias Médicas, Físicas y Naturales de la Habana. Havana, Cuba. Monthly.
Anales del Museo Nacional de México. Mexico. Ir.
Analyst. Des Moines, Iowa. Monthly.
Annales et Bulletin de la Société de Médecine de Gand. Ghent, Belgium. Monthly.
Annales des Mines. Paris, France. Bi-monthly.
Annales des Ponts et Chaussées. Paris, France. Monthly.
Annales de la Société d'Horticulture de l'Allier. Moulins, France. Ir.
Annals and Magazine of Natural History. London, England. Monthly.
Annals of the New York Academy of Sciences. New York, N. Y. Ir.
Annuaire de la Société Météorologique de France. Paris, France. Ir.
Antiquary. London. Monthly.
Arbeiterfreund (Der). Berlin, Prussia. Bi-monthly.
Archæological Journal. London, England. Quarterly.
Archiv der Mathematik und Physik. Leipsic, Saxony. Bi-monthly.
Archiv der Pharmacie. Halle a. d. Saale, Prussia. Monthly.

University of

Archiv des Historischen Vereins von Unterfranken und Aschaffenburg. Würzburg. Bavaria. Ir.

Archiv für Anatomie and Physiologie. Leipsic, Saxony. Bi-monthly.

Archiv für Naturgeschichte. Berlin, Prussia. Ir.

Archiv für Pathologische Anatomie, und für Klinische Medicin. Berlin, Prussia. Monthly.

Archives Néerlandaises des Sciences Exactes et Naturelles. The Hague, Holland. Ir.

Archivio per l' Antropologia e la Etnologia. Florence, Italy. Quarterly.

Art Dentaire. Paris, France. Monthly.

Athenæum. London, England. Weekly.

Athenæum Belge. Brussels, Belgium.

Atlanta Republican. Atlanta, Georgia. Weekly.

Atti dell' Accademia Pontifica. Rome, Italy. Ir.

Atti della Società di Acclimazione e di Agricoltura in Sicilia. Palermo, Italy. Monthly.

Auxiliador da Industria Nacional. Rio de Janeiro, Brazil. Monthly.

Bayerisches Industrie- und Gewerbe-Blatt. Munich, Bavaria. Bi-monthly.

Beiträge zur Statistik Mecklenburgs. Mecklenburg-Schwerin, Germany. Ir.

Berliner Entomologische Zeitschrift. Berlin, Prussia. Ir.

Boletin de la Sociedad de Geografía de Madrid. Madrid, Spain. Ir.

Boletin de la Sociedad Mexicana de Geografía y Estadística. Mexico. Ir.

Bolletino. R. Comitato Geologico d' Italia. Rome, Italy. Monthly.

Bolletino della Società Adriatica di Scienze Naturali. Trieste, Austria. Ir.

Bolletino della Società Geografica Italiana. Rome, Italy. Monthly.

British Journal of Photography. London, England. Weekly.

Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg. St. Petersburg, Russia. Ir.

Bulletin de l'Académie de Médecine. Paris, France. Weekly.

Bulletin of the American Geographical Society. New York. Ir.

Bulletin of the Brooklyn Entomological Society. Brooklyn, N. Y. Monthly.

Bulletin du Canal Interocéanique. Paris, France. Bi-weekly.

Bulletin of the Essex Institute. Salem, Mass. Quarterly.

Bulletin Hebdomadaire de l'Association Scientifique de France. Paris, France. Weekly.

Bulletin Météorologique du Nord. Copenhagen, Denmark. Monthly.

Bulletin of the Nuttall Ornithological Club. Cambridge, Mass. Quarterly.

Bulletin de la Société d'Acclimatation. Paris, France. Monthly.

Bulletin de la Société d'Apiculture de la Gironde. Bordeaux, France. Monthly.

Bulletin de la Société d'Agriculture, Industrie, Science et Arts du Département de la Lozère. Mende, France. Monthly.

Bulletin de la Société d'Agriculture, Science et Arts. Poligny, France. Monthly.

Bulletin de la Société d'Agriculture, Sciences et Arts de la Sarthe. Le Mans, France. Ir.

Bulletin de la Société d'Anthropologie de Paris. Paris, France. Ir.

Bulletin de la Société Archéologique de Béziers. Béziers, France. Ir.

Bulletin de la Société Archéologique de l'Orléanais. Orleans, France. Ir.

Bulletin de la Société Centrale d'Agriculture et des Comices Agricoles. Montpellier, France. Ir.

Bulletin de la Société Géologique de France. Paris, France. Ir.

Bulletin de la Société de Géographie. Paris, France. Monthly.

Bulletin de la Société Impériale des Naturalistes de Moscou. Moscow, Russia. Quarterly.

Bulletin de la Société Industrielle de Mulhouse. Mühlhausen, Alsace. Monthly.

Bulletin de la Société Minéralogique de France. Paris.

Bulletin de la Société Philomathique de Paris. Paris, France. Bimonthly.

Bulletin de la Société des Sciences Naturelles de Neuchâtel. Neufchatel, Switzerland. Ir.

Bulletin de la Société Vaudoise des Sciences Naturelles. Lausanne, Switzerland. Ir.

Bulletino della Società Entomologica Italiana. Florence, Italy. Monthly.

Bulletino della R. Società Toscana di Orticoltura. Florence, Italy. Monthly.

Byron. Athens, Greece. Monthly.

Canadian Antiquarian and Numismatic Chronicle. Montreal, Canada. Quarterly.

Canadian Entomologist. Toronto, Canada. Monthly.

Canadian Journal of Science, Literature, and History. Toronto, Canada. Quarterly.

Canadian Naturalist and Geologist. Montreal, Canada. Bi-monthly.

Chemical News. London, England. Weekly.

Chemist and Druggist. London, England. Monthly.

Chicago Field. Chicago, Ill. Weekly.

Cincinnati Lancet and Clinic. Ohio. Weekly.

Cincinnati Medical Advance. Cincinnati, Ohio. Monthly.

Comet. Jackson, Miss. Weekly.

Congressional Record. Washington, D. C. Daily.

Contemporary Review. (Am. reprint.) New York, N. Y. Monthly.

Cosmos. Turin, Italy. Monthly.

Cultivator and Country Gentleman. Albany, N. Y. Weekly.

Deutsche Industrie-Zeitung. Chemnitz, Saxony. Weekly.
Deutsche Rundschau für Geographie und Statistik. Vienna, Austria. Monthly.
Deutsche Vierteljahrschrift für Zahnheilkunde. Leipsic, Saxony. Quarterly.

Eclectic Medical Journal. Cincinnati, Ohio. Monthly.
Émulation Jurassienne. Porentruy, Switzerland. Monthly.
Endowment Journal. Washington, D. C. Monthly.
Engineering and Mining Journal. New York. Weekly.
English Mechanic. London, England. Weekly.
Entomologisk Tidskrift. Stockholm, Sweden. Quarterly.
Erdelyi Muzeum. Klausenburg. Hungary. Monthly.
Essex Institute Historical Collection. Salem, Mass. Quarterly.
Evening Critic. Washington, D. C. Daily.
Evening Star. Washington, D. C. Daily.

Field. London.
Fishing Gazette. London. Weekly.
Foreign Missionary. New York, N. Y. Monthly.
Forest and Stream. New York, N. Y. Weekly.

Gaceta Científica de Venezuela. Carácas, Venezuela. Ir.
Gaceta Medica. Mexico. Monthly.
Gartenfreund. Vienna, Austria. Monthly.
Giornale della R. Accademia di Medicina di Torino. Turin, Italy. Ir.
Giornale Agrario Italiano. Forli, Italy. Bi-weekly.
Giornale ed Atti della Società di Acclimazione e di Agricoltura in Sicilia. Palermo, Sicily.
Graphic. New York. Daily.
Guide du Naturaliste. Paris, France. Bi-weekly.

Harper's New Monthly Magazine. New York, N. Y. Monthly.
Harper's Weekly. New York. Weekly.
Herald of Peace. London, England.
Historical Collections of the Essex Institute. Salem, Mass. Quarterly.

Ibis, a Magazine of General Ornithology. London, England. Quarterly.
Internationale Freundschafts- & Handels-Beziehungen mit Südamerika, Nordamerika, Australasien, Indien, China, Japan, etc. Vienna, Austria. Weekly.
Inter-Ocean. Chicago, Ill. Daily.
Investigateur. Paris, France. Monthly.
Irrenfreund. Heilbronn, Würtemberg. Monthly.
Italia Agricola. Milan, Italy. Bi-Weekly.

Jahrbücher für die Deutsche Armee und Marine. Berlin, Prussia. Monthly.

Jahrbuch der K. K. Geologischen Reichsanstalt. Vienna, Austria. Quarterly.

Jenaische Zeitschrift für Medicin und Naturwissenschaft. Jena, Saxe-Weimar. Ir.

Journal of Academy of Natural Sciences of Philadelphia. Philadelphia, Pa. Quarterly.

Journal of the Agricultural and Horticultural Society of India. Calcutta, India. Ir.

Journal of the Royal Agricultural Society of England. London, England. Half-yearly.

Journal of the Anthropological Institute of Great Britain and Ireland. London, England. Quarterly.

Journal of Applied Sciences. London, England. Monthly.

Journal of the Asiatic Society of Bengal. Calcutta, India. Quarterly.

Journal of the Royal Asiatic Society of Great Britain and Ireland. London, England. Quarterly.

Journal [formerly Archives] of Comparative Medicine and Surgery. New York, N. Y. Quarterly.

Journal of Conchology. Leeds, England. Quarterly.

Journal of the Royal Dublin Society. Dublin, Ireland. Ir.

Journal of Education. Quebec, Canada. Monthly.

Journal of Education. Toronto, Canada. Monthly.

Journal of the Franklin Institute. Philadelphia, Pa. Monthly.

Journal Général de l'Instruction Publique. Paris, France. Weekly.

Journal of the Royal Geological Society of Ireland. Dublin, Ireland. Ir.

Journal of the Royal Historical and Archæological Association of Ireland. Kilkenny, Ireland. Quarterly.

Journal d'Hygiène. Paris, France. Weekly.

Journal of the Institute of Actuaries. London, England. Quarterly.

Journal de l'Instruction Publique. Montreal, Canada. Monthly.

Journal für Landwirthschaft. Celle, Germany. Quarterly.

Journal Mensuel des Travaux de l'Académie Nationale, Agricole, etc. Paris, France. Monthly.

Journal of the Royal Microscopical Society. London, England. Bi-monthly.

Journal of Nervous and Mental Diseases. Chicago, Ill. Quarterly.

Journal and Transactions of the Photographic Society of Great Britain. London, England. Monthly.

Journal of the Proceedings of the Linnean Society of London. London, England. Ir.

Journal des Savants. Paris, France. Monthly.

Journal of Science. Chicago, Ill. Monthly.

Journal of the Scottish Meteorological Society. Edinburgh, Scotland. Ir.

Journal of the Statistical Society. London, England. Quarterly.

Journal de la Société Centrale d'Horticulture. Paris, France. Monthly.

Journal of the Society of Arts. London, England. Weekly.

Kansas City Review of Science and Industry. Kansas City, Mo. Monthly.
Kunst im Gewerbe. Hanover, Prussia. Bi-monthly.

Land and Water. London, England. Weekly.
Landwirthschaftliche Jahrbücher. Berlin, Prussia. Bi-monthly.
Land- u. Forstwirthschaft. Zeitung der Provinz Preussen. Königsberg, Prussia. Weekly.
Life-Boat. London, England. Quarterly.
Live-Stock Journal. London, England.
London, Edinburgh and Dublin Philosophical Magazine, etc. London, England. Monthly.
London Illustrated News. London, England. Weekly.
La Lumière Électrique. Paris, France. Monthly.

Madras Journal of Literature and Science. Madras, India. Ir.
Magazin für die Literatur des Auslandes. Berlin. Weekly.
Manual of Conchology. Philadelphia. Quarterly.
Maryland Farmer. Baltimore, Md. Monthly.
Matériaux pour l'Histoire primitive et naturelle de l'Homme. Toulouse, France. Monthly.
Medical Advance. Cincinnati, Ohio. Monthly.
Medical and Surgical Reporter. Philadelphia, Pa. Weekly.
Medical Times. London. Weekly.
Memorabilien. Heilbronn, Würtemberg. Monthly.
Memorie della Società degli Spettroscopisti Italiani. Palermo, Italy. Monthly.
Mémoires d'Entomologie. The Hague, Netherlands.
Messager Agricole. Montpellier, France. Monthly.
Messager Franco-Américain. New York, N. Y. Daily.
Messenger of Peace. New Vienna, Ohio. Monthly.
Meteorologische Beobachtungen. Zurich, Switzerland. Ir.
Meteorological Observations made at the Government Observatory. Sydney, New South Wales. Monthly.
Midland Naturalist. Birmingham, England. Monthly.
Mineralogical Magazine. Truro, England. Quarterly.
Mining Record. New York. Weekly.
Mittheilungen der Anthropologischen Gesellschaft. Vienna, Austria. Ir.
Mittheilungen aus dem Gebiete des Seewesens. Pola, Austria. Ir.
Mittheilungen der K. K. Geographischen Gesellschaft. Vienna, Austria. Monthly.
Mittheilungen aus Justus Perthes Geographischer Anstalt. Gotha, Saxe-Koburg-Gotha. Monthly.
Mittheilungen des K. K. Oesterr. Museum für Kunst u. Industrie. Vienna, Austria. Ir.
Mittheilungen der Schweizerischen Entomologischen Gesellschaft. Schaffhausen, Switzerland. Monthly.

Mittheilungen des Vereins für Hamburgische Geschichte. Hamburg, Germany. Ir.

Monatsbericht der Königl. Preuss. Akad. der Wissenschaften zu Berlin. Berlin, Prussia. Monthly.

Monthly Index. New York. Weekly.

Monthly Record of the Five Points House of Industry. New York, N. Y. Monthly.

Morphologisches Jahrbuch. Leipsic, Saxony. Quarterly.

Nation. New York. Weekly.

National Republican. Washington, D. C. Daily.

Naturaliste Canadien. Cap Rouge, Quebec, Canada. Monthly.

Nature. London, England. Weekly.

Naturaleza. Mexico. Ir.

Naturforscher. Berlin, Prussia. Weekly.

Naturhistorisk Tidskrift. Copenhagen, Denmark. Ir.

Neue Deutsche Gewerbe-Zeitung. Leipsic, Saxony. Bi-monthly.

New England Historical and Genealogical Register. Boston, Mass. Quarterly.

New York Medical Eclectic. New York, N. Y. Monthly.

New York Tribune. New York, N. Y. Daily.

Nineteenth Century. (American reprint.) New York, N. Y. Monthly.

Nordisk Tidskrift för Filologie. Copenhagen, Denmark.

North American Review. New York. Monthly.

Northwestern Trade Bulletin. Milwaukee, Wis. Weekly.

Notizblatt des Deutschen Vereins für Fabrication von Ziegel, Thonwaaren, Kalk und Cement. Berlin, Prussia. Quarterly.

Nouvelles Météorologiques. Paris, France. Ir.

Numismatic Chronicle and Journal of the Numismatic Society. London, England. Quarterly.

Nuovo Giornale Botanico Italiano. Pisa, Italy. Quarterly.

Nyt Magazin für Naturvidenskabernes. Christiania, Norway. Quarterly.

Observatory. London, England. Monthly.

Oesterr-Ungar. Fischerei-Zeitung. Vienna, Austria. Weekly.

Oesterreichisch-Ungarische Sparkassen-Zeitung. Vienna, Austria. Weekly.

Our Dumb Animals. Boston, Mass. Monthly.

Penn Monthly Magazine. Philadelphia, Pa. Monthly.

Pharmaceutical Journal and Transactions. London, England. Monthly.

Pharmacist. Chicago, Ill. Monthly.

Philadelphia University Journal of Medicine and Surgery. Philadelphia, Pa. Monthly.

Photographische Correspondenz. Vienna, Austria. Monthly.

Popular Science Monthly. New York. Monthly.

Popular Science Review. London. Quarterly.

Prairie Farmer. Chicago, Ill. Weekly.
Psyche. Cambridge, Mass. Monthly.
Public Ledger. Philadelphia, Pa. Daily.
Pubblicazioni del Circolo Geografico Italiano. Turin, Italy. Bi-monthly.
Publishers' and Stationers' Weekly Trade Circular. New York, N. Y. Weekly.
Publishers' Weekly. New York. Weekly.
Puck. New York, N. Y. Weekly.

Quarterly Journal of the Chemical Society. London, England. Monthly.
Quarterly Journal of the Geological Society of London. London, Eng.
Quarterly Journal of the Meteorological Society. London, England.
Quarterly Weather Report of Meteorological Office. London, England.

Reading Times and Dispatch. Reading, Pa. Daily.
Republic. Washington. Weekly.
Revue Agricole, Industrielle, Littéraire et Artistique. Valenciennes, France. Monthly.
Revue Géographique Internationale. Paris, France. Monthly.
Revue Maritime et Coloniale. Paris, France. Monthly.
Revue Médicale de Toulouse. Toulouse, France. Monthly.
Revue Politique et Littéraire. Paris, France. Weekly.
Revue Savoisienne. Annecy, France. Monthly.
Revue Scientifique de la France et de l'Étranger. Paris, France. Weekly.
Revista de la Arquitectura. Madrid, Spain. Monthly.
Revista Científica Mexicana. Mexico. Monthly.
Revista General de Comunicaciones. Havana, Cuba. Monthly.
Royal Astronomical Society. London, England. Monthly notices.

Sanitarian. New York. Monthly.
Schulzeitung für die Herzogthümer Schleswig-Holstein und Lauenburg. Kiel, Prussia. Weekly.
Science Gossip. London. Monthly.
Science Observer. Boston, Mass. Monthly.
Scientific American. New York, N. Y. Weekly.
Scientific American Supplement. New York. Weekly.
Scottish Naturalist. Edinburgh, Scotland. Quarterly.
Sitzungsberichte der Naturw. Gesellschaft Isis. Dresden, Saxony. Monthly.
Société Centrale des Architectes. Paris, France. Monthly.
Société Linnéenne du Nord de la France. Amiens, France. Monthly.
Symons's Monthly Meteorological Magazine. London, England. Monthly.

Technische Blätter. Prague, Austria. Quarterly.
Telegraph Journal. London. Weekly.
Tijdschrift voor Entomologie. Leiden, Holland. Ir.

Tidsskrift for Populære Fremstillinger af Naturvidenskabern. Copenhagen, Denmark. Ir.
Tidsskrift for Veterinairer. Copenhagen, Denmark. Quarterly.

Ungarische Revue. Vienna, Austria. Ir.
Urania. Dublin, Ireland. Monthly.

Vereinigte Frauendorfer Blätter. Passau, Bavaria. Weekly.
Vierteljahrschrift der Astronomischen Gesellschaft. Leipsic, Saxony. Quarterly.
Vierteljahrschrift der Naturforschenden Gesellschaft in Zürich. Zurich, Switzerland. Quarterly.
Volksvligt, Tijdschrift voor Nijverheid, Landbow, Handel en Scheepvaart. Amsterdam, Holland. Monthly.

Washington Post. Washington, D. C. Daily.
Washington Sentinel. Washington, D. C. Weekly.
Wiener Illustrirte Garten-Zeitung. Vienna, Austria. Monthly.
Wochenschrift des Oesterreichischen Ingenieur- und Architecten-Vereines. Vienna, Austria. Weekly.
Wochenschrift des Vereines Deutscher Ingenieure. Berlin, Prussia. Weekly.

Zeitschrift des Architecten- und Ingenieur-Vereins für das Königreich Hannover. Hanover, Prussia. Quarterly.
Zeitschrift der Deutschen Geologischen Gesellschaft. Berlin, Prussia. Quarterly.
Zeitschrift der Deutschen Morgenländischen Gesellschaft. Leipsic, Saxony. Quarterly.
Zeitschrift des Oesterreichischen Ingenieur- und Architekten Vereins. Vienna, Austria. Monthly.
Zeitschrift des Vereines Deutscher Ingenieure. Berlin, Prussia. Monthly.
Zhurnal Russkago Khimitsheskago Obschestva. St. Petersburg, Russia. Ir.
Zoologische Garten. Organ der Zoologischen Gesellschaft. Frankfort on the Main, Prussia. Monthly.
Zoologist. London, England. Monthly.

RULES FOR THE EXAMINATION OF SPECIMENS SUBMITTED TO THE SMITHSONIAN INSTITUTION.

1. *Qualitative* examinations—that is, for determining the constituents of the specimens—are made without charge.

2. *Quantitative* examinations, or the determination of the *percentage* of the different components of the specimens, can only be made at the expense of the applicant; the charge to be in proportion to the time expended in the work, *e. g.*, from $5 to $50, according to whether it is *partial* (determination of silver, lead, or iron, &c., only) or *full* (determination of everything).

3. The report of *quantitative* examinations will be given under the name of the *expert* to whom the specimens shall be submitted, and not under that of the Smithsonian Institution.

4. All applications for the determination of specimens must be made by letter, addressed "Secretary of the Smithsonian Institution."

5. The specimens examined, or a part of them, will be retained by the Institution.

6. All specimens to be delivered to the Institution free of expense.

SPENCER F. BAIRD,
Secretary Smithsonian Institution.

REPORT OF FRED. W. TAYLOR,

Chemist of the Smithsonian Institution.

The present chemist entered upon his duties the latter part of January, 1880, taking charge of the laboratory and mineralogical department during the absence of Dr. Endlich, and has continued to perform the duties of his office since that time. The laboratory was found to be in comparatively good order, though the stock of apparatus and chemicals was extremely limited. By slow additions the stock of both has been largely increased, until now the laboratory may be said to be comparatively well supplied for all branches of inorganic work. As yet no provision has been made for organic work, and no such work has been attempted, as, in addition to the lack of apparatus, the arrangement and fitting of the laboratory render such work almost impossible. As stated in the last annual report, the work of the laboratory consists in the determination of various minerals sent in to the Institution for identification, and in the investigation of such questions as may be referred to it by the departments. No other work is attempted by the Institution, though the chemist is kindly permitted to undertake other work on his own account. Since February 1, 1880, the chemist has made about one hundred and twenty qualitative reports to the Institution on specimens received, identifying nearly three times that number of specimens; also some fifteen quantitative reports. He regrets, however, that nearly ninety per cent. of the specimens received by the Institution are entirely worthless, owing to the small size of specimens, and to the partiality of senders to the sulphide of iron (Pyrite) and to the sulphide of iron and copper (Chalcopyrite). This unfortunate fact has prevented the chemist from making any considerable addition to the collection, or to the supply of duplicates. The cases in the mineral hall have, however, been refitted and put in order without change in the system followed by Dr. Endlich, and the few valuable specimens that have been received, where space would not permit their exhibition, have been temporarily stored in the drawers under the cases. Among the specimens of value received may be mentioned specimens of amalgam, crude bullion, and fine silver from Montana, received from Mr. Thos. Donaldson; a small but handsome collection of minerals from Mr. Geo. F. Kunz, of New York; some fine specimens of native copper, contributed by Dr. Reynolds; and a large number of specimens of the gold and silver ores of the West, from the surveyors-general of the Western States. Here let me enter a respectful protest against the method of collecting these specimens. I should not say method, however, as my protest is against the apparent want of any method or system whatever. As received the specimens are of every size and shape, from a mere chip to a piece of three inches cube, some labeled or numbered, some not. I would suggest that each contributor of such specimens be requested to send pieces of something like the same size, say 4″ × 6″ × 2″; that each specimen be sent in duplicate, and that in all cases an invoice of specimens be sent both with the letter of transmittal and also inclosed with the specimens. We would then have a fair collection of these ores instead of the present supply of chips, many of them broken from the weathered outcrop of the ledge or vein which they are intended to represent. Another collection received has been one of the gold, silver, and copper ores of Alaska, from Com. L. A. Beardslee; a collection of iron, lead, and copper ores of South Africa, from Mr. Geo. D. Sidman. Mr. F. A. Lowe has contributed a fine specimen of Ammikite and one of Huntilite, the two new silver islet minerals, the first containing eighty per cent. of silver, also a small specimen of Macfarlanite. Though the chemist has not as yet completed any sets of duplicates for distribution, he has sent off several sets that were packed by Dr. Endlich, and has under way some fifteen or twenty more sets for that purpose.

These sets will contain not only minerals, but also a certain number of lithological and geological specimens, the aim being to furnish a set of characteristic minerals and ores for class teaching. Among the questions referred to the Institution by the departments was that of the utility of the Tichnor process for the extraction of gold from its ores, referred by the Patent Office. This investigation was a most tedious and laborious one, involving many weighings of a deliquescent substance, which had to be done with the greatest rapidity, and at the same time with accuracy; also the making of some fifty careful assays, giving the chemist nearly a month of hard and dirty work. Another question referred to the chemist through Mr. Rhees, of the Institution, was the character of the coloring matter used on the small squares of paper given to the children in the Kindergarten schools of the District and elsewhere. This paper is a thin paper, colored and glazed on one side (in most cases), cut into five-inch squares, and is given to the children to cut up and fashion into various patterns.

The chemist regrets that he has not been able to find time to make more than a brief qualitative examination of the subject. Eighteen samples of paper were tested for arsenic, and out of that number six samples were found to contain a large amount of arsenic in different forms, probably the most dangerous being a bright green paper, the coloring matter being the brilliant but deadly Scheele's green. The other colors found to contain arsenic were purple, solferino, navy blue, carmine red, and vermillion red. Another investigation undertaken by the chemist for prominent private parties was a thorough testing of the so-called Robertson electric process for the reduction of gold ores. This process, like the Tichnor, is utterly at variance with accepted ideas of chemists and metallurgists, and the investigation showed similar results to the Tichnor in proving it of little value. In addition to these investigations the chemist has undertaken numerous analyses and assays for private parties of no particular chemical interest. The time of the chemist has of late been entirely occupied in overhauling and recording the vast amount of reserve material stored in the Institution, the object being to make a complete record of duplicates and reserves and to eliminate all worthless material and make room for new contributions.

ADDITIONS TO THE COLLECTIONS OF THE NATIONAL MUSEUM IN 1880.*

Abbey and Imbrie. A large collection of fishing-tackle (purchased). B. E.

Acton, H. B. (*through Miss Foster*). A fossil shell; from Mexico.

Adams, W. H. A small box of fossils; from Illinois.

Adkins, G. B. A living land-tortoise (*Cistudo clausa*); from Virginia.

Agarsbury, G. S. A hawk (*Buteo swainsoni*).

Alaska Commercial Company, San Francisco, Cal. Two skeletons of pup seals; from Alaska.

Aldrich, C. B. A small collection of Indian implements; from Iowa.

Allen, C. A. Specimens of birds; from California..

Allen, Walter. Specimens of rock; from Maryland.

Anderson, W. A., and H. C. Harrison. A specimen of leather-back turtle (*Sphargis coriacea*); from York River, Virginia.

Andross, William W. A stone ax; from Connecticut.

Angus, J. Specimens of mineral; from North Carolina.

Atkins, Charles G. Samples of salmon-hatching trays and frames used at Bucksport, Me.; and a model of fishway, at Bangor, Me.

Atkinson, Edward. Samples of silk-weaving from the Glasgow Industrial School.

Atwood, Capt. N. E. Samples of cod-liver oil; from Provincetown, Mass.

Babcock, Dr. S. E. (*through Charles Rau*). Samples of mica; from Chester County, S. C.

Barker, Henry L. Specimens of living snakes (*Coluber*), and turtles (*Pseudemys scabra*); from South Carolina.

Ballou, J. N. Specimen of mineral; from North Carolina.

Banta, W. V. Specimen of Indian pottery; from Iowa.

Barbour, John S. (*through John T. Harris*). Sample of coal; from Virginia.

Barnett, G. W. Specimens of mineral; from Texas.

Barry, J. Thomas. Specimens of mountain blacksnake (*Coluber obsoletus*); from Maryland.

Bartlett, J. H., & Sons, New Bedford, Mass. Samples of whale oils and bone.

Bassett, Wm. H. Spawn of scup; from New Bedford, Mass.

Bateman, J. F. Specimen of salamander; from Maryland.

Beach, M. S. Specimen of mineral; from Wisconsin.

Bean, Capt. J. W. A young *Crotaphytus;* from New Mexico.

Bean, Dr. T. H. Specimens of fish (*Centrarchus*, *Pomoxys*, *Chænobryttus*, *&c.*, *&c.*); from North Carolina. Specimens of shad from the Potomac River. Carpet-loom and appurtenances used in 1819. (See, also, Washington, United States Commission Fish and Fisheries.) Very large general collections of natural history and ethnology, from Alaska and the Arctic Ocean. (See, also, Dall.)

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*NOTE.—Contributions made through the United States Commission of Fish and Fisheries may be found in the list of additions under Washington, D. C.

Beard and Thomas. Two photographs of jaw of mastodon, found in Nebraska.

Beardslee, Commander L. A., U. S. N. Specimens of minerals, corals, fishes, birds, and ethnologica; from Alaska.

Beardsley's (J. W.) Sons, New York. Seven cases of canned and boxed fishes.

Beckwith, H. C., Acting Assistant Engineer, U. S. N. Specimens of cretaceous fossils; from Colorado.

Belding, L. A large number of specimens of the skins, nests, and eggs of birds, living snakes, toads, &c., plants and Indian relics; from California.

Bell, James, United States Land Office. A large collection of living snakes, specimens of birds skins, nests, and eggs, Indian relics, and crania, from mounds, &c.; from Florida.

Bendire, Capt. Charles, U. S. A. Specimens of birds skins, nests, and eggs; grasshoppers and fishes; from Fort Walla Walla, Washington Territory.

Benecke, Lewis. Specimen of spider (*Acrosoma rugosa, Hentz.*); from Missouri.

Benner, D. J. Specimens of cocoons of silk-worms and silk; from South Carolina.

Bennett, Richard. Specimens of minerals; from Arkansas.

Berry, Mrs. R. P. Human skull; from Newport, R. I.

Billings, Melvin. A box of Indian relics, pottery, &c.; from Kansas.

Binney, W. G. A large collection of terrestrial mollusca, identified and labeled, constituting his original collection and the types of his work.

Birney, H. H. A specimen of living snake (*Leptophis æstivus*); from Washington, D. C.

Bishop, H. J. M. Specimens of invertebrates; from Connecticut.

Blackford, E. G. A large number of specimens of fishes taken along the Atlantic coast of the United States, from Maine to Florida.

Blosier, H. A specimen of tailor shad (*Dorosoma cepediana*); from Ohio.

Boardman, George A. Male and female of Barrows' golden-eye duck.

Boehmer, George H. A deformed chicken, minerals, Indian stone hammer, snakes, and muskrat; from Maryland.

Booth, A., Chicago, Ill. Five cases of preserved salmon and one case of oysters.

Booth, M. A. Specimens of diatomaceous earths; from Long Island Sound.

Boston (The) Humane Society, Boston, Mass. Box of charts, medals, &c., issued by the society.

Borland, Dr. A. M. Four boxes of Indian implements and fossils; from Arkansas.

Bowie, *Osborne.* A living turtle (*Emys rugosa*); from Virginia.

Bowron, *W. M.* Specimens of Septa; from Virginia.

Brackin, *Alfred.* Iron pyrites; from North Carolina.

Bradfield, *H. L.* Specimen of silicified wood; from West Virginia.

Bradford and Anthony, *Boston*, *Mass.* A collection of fishing tackle.

Brady, *Rev. John* (*through W. H. Dall*). Specimens of smelt (*Osmerus pacificus*); from Alaska.

Braunstein, *John A. J.* Two grooved axes and a number of arrowheads; from Maryland.

Breedon, *Jacob.* Photographs of *Castoroides ohiensis.*

Brewer, *Samuel.* Specimens of mineral; from Virginia.

Britton, *W. A.* Rock specimens; from Arkansas.

Broadhead, *Prof. G.* Box of fossils; from Missouri.

Broadus, *A.* Specimens of *Pyrolusite*; from Virginia.

Brodhead, *Ross B.* Young living alligators; from Florida.

Brock, *R. A.* Specimens of scoria from iron furnace.

Brown, *J. B.* Specimens of locusts; from Ohio.

Brown, *J. J.* Specimens of *Planorbis*; from Wisconsin.

Brown, *N. C.* Specimens of bird-skins; from Maine.

Brown, *S. C.* Tank of alcoholic fishes, reptiles, &c.; from Western New York.

Bryan, *Oliver N.* Specimens of fungi; from Maryland.

Bryant, *B. D., jr.* Specimens of conglomerate; from Maine,

Bullen, *George W.* Specimens of minerals; from Washington Territory.

Bunn, *Joseph.* Scales of alligator-gar (*Lepidosteus*).

Burns, *Frank.* Specimens of rock; from Alabama.

Burr, *Dr. R. T.*, *U. S. A.* A collection of plants and insects, and alcoholic reptiles; from Arizona.

Burtele, *E.* A box of shells; from Alabama.

Bush, *Mrs. A. E.* Specimens of California mosses.

Busy, *John H.* Specimens of quartz; from Maryland.

Butler, *Amos W.* A collection of Indian arrow- and spear-heads; from Illinois.

Caldwell, *S. D.* Skin of bittern (*Botaurus lentiginosus*); from District of Columbia.

Call, *Wilkinson*, *U. S. Senate.* Specimens of copper ore; from New Mexico.

Cambridge, *Mass.*, *Museum of Comparative Zoölogy*, *Prof. Alexander Agassiz*, *Director.* A collection of North and South American fishes.

Campbell, *Charles D.* A grooved stone; from Ohio.

Campbell, *J. B.* Two fossils; from California.

Cannon, *William.* Clay pipe; from Florida.

Carpenter, *Charles.* Specimen of sucker (*Catostomus longirostris*); from Lake Erie.

Carpenter, *C. A.* Specimens of minerals; from Arizona.

Caton, *Judge J. D.* Skull of *Hydropotes inermis.*

Chamberlain, M. Specimen of gull; from New Brunswick.

Chambers, D. M. Specimen of snake (*Storeria occipitomaculata*); from New York.

Chameuret, W. M. Specimens of iron ore; from Alabama.

Chandlee, John F. Stone axe; from the Susquehanna river, Pennsylvania.

Chandler, Capt. R., U. S. N. Specimen of crab; from the Samoan Islands.

Chase, Edward A. Pair of scissors taken from stomach of cod.

Chastain, J. T. Specimen of thread-herring (*Opisthonema thrissa*); from Georgia.

Chester, H. C. Model of fishing boat.

Choate, W. R. Skull of Indian chief.

Christian, H. A. Mounted specimen of dab-chick (*Podilymbus podiceps*); from Ohio.

Chubb, H. E. A mounted specimen of "Kirtland warbler"; from Ohio.

Churchill, J. H. A specimen of star-nosed mole; from New York.

Cincinnati, Ohio, Cuvier Club. A collection of bird skins.

Clark, Frank N. Box of fish-hatching apparatus, eggs of white-fish, and specimens of fish from Lake Michigan.

Clark, Robert. Specimen of mole (*Microsorex hoyi*); from Colorado.

Clarke, Samuel C. Specimens of insects; from Florida.

Clarke, Walker. Two boxes of minerals; from New Mexico.

Clayton, C. T. Skin of bird; from Maryland.

Cleneay, Thomas. Box of stone implements; from Ohio.

Coale, H. K. Collection of bird-skins, 45 species and 112 specimens.

Cockerill, Stanard. Specimen of grass-snake (*Cyclophis æstivus*).

Cole, C. A. Two cases of "Irish" moss; from Massachusetts.

Coleman, G. S. Specimen of rock; from Virginia.

Collier, Carl (through L. Belding.) Indian stone tube; from California.

Collins, G. H. Box of birds; from Fort Laramie, W. T.

Colvan, E. Deformed catfish (*Amiurus albidus*); Potomac River.

Conrad, L. Specimens of mineral; from Ohio.

Conroy, Bissett & Malleson, New York City. Eight boxes of fishing rods, flies, and general camp outfit (purchased). B. E.

Cook, Richard E. Specimens of iron-ore; from Alabama.

Cookselle, Stanley. Ten specimens of arrow-heads.

Cooper, George H. Ball of hair taken from stomach of cow, and two arrow-heads; from Virginia.

Copley, James D. Knife made from human bone; from Sullivan County, New York.

Corker, Capt. S. M. (through C. C. Leslie). Specimens in alcohol of fish and shells taken by the smack "H. E. Thompson," of Charleston, S. C.

Cornwall, Prof. A. R. Jaw of blackfish (*Phocæna americana*).

Corson, J. N. K., U. S. A. Living tortoise (*Testudo agassizii*) and lizard (*Sceloporus*); from California.

Coues, Dr. Elliott, U. S. A. Specimens of mammals, birds, and bird's nest and eggs.

Cox, Capt. James V. Model of South Sea Island dug-out canoe.

Crawford, Capt. E., U. S. A. Eighteen boxes of fossils; from Dakota.

Cromwell, Capt. Levi. Head of sail-fish (*Histiophorus americanus*); from off Barnegat.

Culler, Peter. Box of minerals; from Maryland.

Dall, W. H. and T. H. Bean. Forty-seven boxes of general natural history and ethnological collections; from Alaska.

Damusure, Edwin. Living black-snake (*Bascanion constrictor*).

Daniel, F. V. Package of fossils; from Texas.

Daniel, L. S. Specimen of mineral; from Texas.

Darrow, J. W. Specimens of insects; from Kentucky.

Davis, A. E. Specimens of insects; from Arizona.

Davis, H. G., U. S. Senate. Specimens of minerals; from West Virginia.

Davis, Joshua. Small box of stone implements; from Maryland.

Dennison, E. W. Trout, weighing eleven pounds; from Rangeley Lake, Me. (Purchased.)

Dent, J. P. Specimens of minerals.

Detwiler, S. S. Box of minerals; from Pennsylvania.

Dickinson, E. Collection of bird's nests; from Massachusetts.

Doak, M. S. Two boxes of minerals; from Tennessee.

Dodge, Lieut. Col. Richard I., U. S. A. Box of plants and flowers; from California.

Domnitz, H. Specimens of terrapins (*Pseudemys picta*). (Purchased.)

Donaldson, Thomas. Eight boxes of minerals; from the "Lexington Mine," Montana.

Doron, T. S. Specimens of fish, Indian relics, and skin of wild-cat (*Lynx rufus*); from Alabama.

Dorsey, R. B. Specimen of fossil (*Aturia*); from California.

Dowell J. C. Six specimens of herons.

Downman, R. H. Specimens of pike (*Esox americana*) and insects; from Virginia.

Drane, Dr. O. A. Stone ax; from Saint George County, Md.

Driver & Schofield. Specimen of monkey (*Cercopithecus*).

Dudley, W. L. Section of fossil tree; from Kentucky.

Dugés, Prof. Alfredo. Box of birds' skins, insects, reptiles, &c.; from state of Guanajuato, Mexico.

Dummon, Richard. A living blind chicken.

Durand, Wm. S. Plant; from Michigan.

Dupre, D. A. Specimens of minerals; from South Carolina.

Earll, R. E. Nine boxes and tanks of fresh and alcoholic specimens of fishes from various places along the Atlantic coast of the Southern States; fishing gear used in Florida and the Carolinas; yoke for patent knee of dory; one fish-sound extractor; a collection of fish sounds, and samples of Yupon tea, from North Carolina.

Earll, R. E., and M. McDonald. Two tanks of alcoholic specimens of fishes; from North Carolina.

Easterday, Geo. W., and J. R. Bachtell. Specimens of minerals; from Beaver Creek, Md.

Edmonds, Richard H. Two cases of canned crabs and specimens of oyster shells, also photographs of fish-canning establishments.

Edwards, Vinal N. Nine boxes of alcoholic specimens of fishes; from Wood's Holl, Mass.

Eisen, Gustaf. A collection of alcoholic specimens of reptiles; from California.

Elegat, William B. A specimen of trilobite; from Ohio.

Endlich, F. M. Specimens of hunting implements used by the Wapsiana Indians of British Guiana; skins of jaguar and monkey, and dried specimens of trunk and flying fishes; also aboriginal West Indian pottery.

English, Commodore Earl, U. S. N. Specimens of minerals.

Esperson, Hon. Henry, Surveyor-General, Dakota. Three boxes of minerals; from various mining claims in Dakota.

Evans, C. H. Specimen of graphite.

Evans, Commander R. D., U. S. N. Two boxes of soundings; from the North Atlantic, taken by the United States steamer Saratoga during the years 1879 and 1880.

Fair, A. D. M. Box of shells; from Honduras. A small box of fossils; from New Jersey; and teeth of porbeagle shark.

Fairbanks, N. K. (through A. Booth.) Specimens of California salmon taken in Geneva Lake, Wisconsin.

Falkiner, W. R. Specimen of *asbestos;* from Virginia.

Farquhar, Col. F. U., U. S. A., Secretary Light-House Board. A large collection of corals; from the Tortugas, Florida.

Findley, J. J. Specimens of minerals; from New Mexico.

Findley, S. M. Hawk (*Buteo borealis*); from Virginia.

Figyelmesy, Philip, United States consul Demarara, British Guiana. Bark canoe and paddles, and collection of pottery and basket-work; made by the Indians of British Guiana.

Fisher, W. J. Mollusks; from Maine.

Fitch, Captain. Nest of Brazilian oriole.

Fitzhugh, D. H. Specimen of fish (*Percopsis pellucida*); from Michigan.

Fleetwood, William A. Specimen of pointer.

Fletcher, Thomas. Small box of minerals; from Arkansas.

Forns, Raymond W. Mounted specimens of birds.

Forney, George H. Specimens of minerals; from New Mexico.

Fox, Hannibal. Metallic mask; from Ohio (lent for casting).

Friedricksten, Count A. von Donhoff. Stone mask (lent for casting).

Frinckel, George N. Specimen of talc.

Frizzell, Bernard F. Specimen of flying squirrel (*Sciuropterus volucella*); from Washington, D. C.

Fullen, Andrew. Small box of minerals; from West Virginia.

Furber, F. B. Specimens of minerals; from Texas.

Furr, Charles E. Specimen of iron pyrites.

Galbraith, Frank G. Two boxes Indian implements and one tank of alcoholic specimens of fishes; from Lancaster County, Pa.

Galindo, Don Ignacio (through Dr. E. Palmer). Mummy and surroundings; from cave at Coahuila, Mexico.

Galliher, N. M. Specimen of ore; from Virginia.

Garlick, Theodatus. Two casts of fishes.

Garnier, John H. Specimens of snakes; from Ontario.

Garratt, A. (through Dr. Hartmann). Stone ax; from the Society Islands.

Gearn, W. R. Seeds of *Chenopodium*, taken from Indian mound in Dakota.

Gere, J. E. Box of Indian relics; from Wisconsin.

Gernerd, J. M. M. Specimens of fossiliferous rocks; from Pennsylvania.

Gesner, William. Living specimens of mussels; from Alabama.

Gibbs, George J. Deposit taken from old salt pond, Grand Turks Island, W. I.

Gilbert, Charles H. Four tanks alcoholic specimens of fishes; from the Pacific coast of the United States. See also under Jordan, D. S.

Gilbert, G. K. One tank and box of alcoholic specimens of fishes; from Utah.

Gilliss, Capt. James, U. S. A. Pair of elk antlers; from Wyoming.

Gloss, Joseph D. Living box tortoise (*Cistudo clausa*); from the District of Columbia.

Gloucester (Mass.) Isinglass and Glue Company. Four boxes of samples of isinglass, glue, &c.

Glover, Prof. Townend. Case of mounted specimens of birds.

Goodale, S. L. Sample of food extract of mackerel.

Gookin, N. W. Samples of beet sugar and sirup.

Goss, N. S. Bird-skin; from Briers' Island, N. Scotia.

Gough, Stephen E., jr. Two living horned frogs (*Phrynosoma*).

Grop, L. Box of fossil ferns; from Arkansas.

Graham, A. H. Osteological specimens; from mound in Texas.

Gray, Professor Asa. Four Indian implements (lent for casting).

Gray, S. C. Sample of soapstone; from Ohio.

Greely, Lieut. A. W., U. S. A. Pharyngeal bones of drum (*Pogonias chromis*); from Sandy Hook.

Green, Lieut. L. D., U. S. A. Portion of skull of bear; from Wyoming Territory.

Green, Seth. Collection of fish-hatching apparatus.

Griffith, C. E. Specimen of blue-tailed lizard; from Maryland.

Griffith, David. Specimens of minerals; from Maryland.

Grigsby, C. S. Water-worn piece of limestone; from Tennessee.

Grigsby, J. B. Specimen of ore; from Tennessee.

Grimes, E. G., U. S. A. Swan; from Yankton, Dakota.

Griscome, J. W. Specimens of *Branchipus*.

Guesde, L. Jar of alcoholic mammals, fishes, and reptiles; from Guadeloupe.

Haines, Macy P. A collection of fossils; from Indiana.

Haller, A. S. Specimens of insects; from Virginia.

Halsted, Miss May A. Lower jaw of fresh-water drum (*Haploidonotus grunniens*); from the Mississippi River.

Hamlen, William. Two fossil oysters, from the Potomac River.

Hampton, Wade, U. S. Senate. Specimens of alligator-gar and shovel-nosed cat-fish (*Litholepis* and *Polyodon*); from the Mississippi River.

Hancock, John. Specimens of minerals; from Arizona and Texas.

Harrison, George B. Bird; from Virginia.

Hartman, Andrew. Stone ax; from York County, Pennsylvania.

Hatch, Philo T. Sample of shell marl; from New York.

Hawes, Dr. G. E. Insect; from Florida.

Hawley, Dr. G. A. Medal of Indian or Mexican make; from Guatemala.

Hayward, F. W. Living specimens of *Siren* and *Amphiuma*; from South Carolina.

Healy, Rev. P. Horned-frog; from California.

Henckle, Ambrose L. Specimens of Indian implements; from Virginia.

Henderson, Judge John G. Four boxes of Indian relics taken from the "Naples Mound," Illinois.

Henderson, S. J. Specimens of minerals; from Ohio.

Henry, L. B. Specimens of minerals; from Virginia.

Henshaw, H. W. A small collection of bird skins; also stone pestle from Idaho.

Hereford, Frank, U. S. Senate. Specimens of minerals; from West Virginia.

Herendeen Capt. E. R. Specimens of stone relics; from the North Pacific Islands.

Hering, C. J. Collection of natural history and ethnological specimens; from Surinam.

Hermes, Dr. Two specimens of eels; from Germany.

Herring & Co., New York. One large burglar and fire proof safe, manufactured expressly for and presented to the U. S. National Museum.

Hess, F. Meteoric stone; from Iowa.

Heyman, Professor. Section of whale vertebra.

Hicks, G. H. Indigo bird (*Cyanospiza cyanea*), and collection of Indian relics; from Michigan.

High, Augustus. Specimens of minerals; from Dakota Territory.

Hill, A. C. Specimens of insects; from Vermont.

Hill, D. D. Minerals; from New Mexico.

Hill, R. T. Specimens of crystals.

Hillman, Prof. Uno. Samples of albumen made from the eggs of the cod.

Hilyer, Prof. Henrico. Alcoholic specimens of fishes and collection of bird skins; from Italy.

Hinston, J. H. Specimen of coal; from Georgia.

Hitchcock, George N. Egg of a gull.

Hitz, Charles. Stone ax.

Hobbs, Orlando. Two boxes of land and fresh-water shells, and Palæozoic fossils; from Indiana.

Hockhaus, F. W. Specimens of iron pyrites; from Iowa.

Hollenbusch, H. H. Box of minerals; from Pennsylvania.

Holliday, J. C. Specimen of meteoric stone; from South Carolina.

Holmes, W. H. Specimens of quartz, calcite, and obsidian; from the Yellowstone National Park.

Horan, Henry. Specimens of living snakes; from Maryland and Virginia.

Horn Silver Mining Company. Specimens of ores.

Howe & French, Boston, Mass. Specimens of American isinglass.

Howgate, Capt. H. W., U. S. A. Two living Eskimo dogs; from Greenland.

Hubbell, — . Specimen of soapstone; from Virginia.

Hughlett, Thomas. Specimens of sea trout (*Cynoscion regalis*) and ribbon-fish; from Maryland.

Hunt, B. A. Collection of ethnological specimens; from Georgia.

Hunter, John. Specimen of decomposed feldspar.

Huntingdon, Charles L., U. S. N. Two boxes of soundings; taken by the U. S. S. Alert in Yeddo Bay, Japan.

Huysman, Theodore (through Dr. C. Rau.) Stone celt; found in the State of Magdalena, United States of Colombia.

Hyams, C. N. Collection of birds' eggs; from North Carolina.

Ingersoll, Ernest. Box of Indian relics; from New York.

Japan, Bureau of Education of (Mombusho). Two boxes of botanical specimens.

Jennings, John. Chunky-stone; from Tennessee (lent for casting).

Johnston, G. W. Specimen of sparrow (*Passerella Townsendi*); from California.

Johnson, Master Samuel M. Albino rat; from South Africa.

Johnson, Samuel M. Collection of Indian pottery and implements, and living tortoise and snake; from Texas.

Jones, Mrs. A. E. Living water-snake (*Tropidonotus fasciatus*); from Virginia.

Jones, Alfred. Leaf, with insect adhering.

Jones, D. A. Specimens of minerals; from Virginia.

Jones, George C. Casts of Indian implements; from Connecticut.

Jones, John P., United States Senate. Specimen of mineral; from Nevada.

Jordan, David S., and Charles H. Gilbert. Sixty-five boxes and tanks of fishes, taken along the Pacific coast of the United States; also, a series of fish preparations for food, &c., obtained in San Francisco.

Jordan, W. N. Specimen of mineral; from South Carolina.

Jouy, P. L. Specimens of fishes, from Washington Market; specimens of snakes and birds, from Maryland; and a large collection of birds, from Cobb's Island.

Kefauver, H. B. Specimen of rock; from Maryland.

Kelly, Moses. Specimen of chromic iron; from Maryland.

Kemp, J. C. Grape-vine borer; from Virginia.

Kendall, J. K. Specimen of barnacle goose; from Jamaica Bay, L. I.

Kenyon, O. A. Specimen of worms; from Iowa.

Kerne, Lieut. L. M., United States Revenue Marine. Arrow-head; from Port Royal, S. C.

Kidder, Dr. J. H. Tank of alcoholic specimens of fishes; from Beyrout, Syria.

Kilby, ———. Egg of turkey-buzzard; from Virginia.

King, Larkin. Specimens of minerals; from Texas.

Kitchen, C. M. Specimens of plants; from Virginia.

Knickerbocker, Millis. Package of seeds, &c.; from Florida.

Knott, John, jr. Specimen of hair-snake (*Gordius*).

Koebele, Albert. Box of birds' skins and eggs, and insects.

Koehler, William. Sample of fish food.

Koontz, George S. Specimen of ore.

Kost, Prof. J. Collection of fossil rocks, &c.; from Michigan.

Kumlien, Ludwig. Leather made from skin of sturgeon; specimen of fish from Lake Ontario; and stuffed skin of salmon from Cape Vincent, N. Y.

Kuntz, George F. Box of minerals.

Langdon, F. W. Box of Indian relics; from Ohio.

Lanphear, G. B. Specimens of fishes.

Latimer, A. W. Fossil; from the Chattahooche River, Alabama.

Latimer, W. H. Stone image; from Porto Rico, West Indies.

Lawrence, Alfred N. Specimen of fish; from New Jersey.

Lawrence, George N. Stone ax; from Essex County, N. J.

Lawrence, Dr. George W. Specimen of thread-herring (*Opisthonema thrissa*); from Arkansas.

Lawrence, Robert. Specimen of dwarf deer.

Lee, Dr. W. Hair-snakes (*Gordius*).

Leppelman, L. Three boxes of Indian relics; from Ohio (lent for casting).

Leslie, Charles C. A collection of fresh and alcoholic specimens of fishes; from South Carolina.

Lewis, L. L. Specimens of plants and rocks; from New York.

Lightburn, Dr. R. E., U. S. A. Living specimen of Gila monster (*Heloderma horridum*); from Arizona.

Lippold, George. Living specimen of snake (*Ophibolus doliatus*); from the District of Columbia.

Locke, W. M. Deformed specimen of soft-shell turtle (*Achedonectes spinifer*); from Illinois.

Logan, John A., United States Senate. Samples of coal; from Illinois.

Longfield, Frank. Specimens of snakes and insects; from Texas.

Lowry, Robert. Albino specimen of snowbird (*Junco hyemalis*); from Virginia.

Luther, S. M. Specimens of Indian relics; from Ohio and Michigan (lent for casting).

Luttrell, Chester. Box of Indian relics; from Alabama.

Luttrell, Elston. Three boxes of ethnological and mineralogical specimens; from Alabama.

Lyon, V. W. Two boxes of fossils; from Indiana.

Maddox, W. L. Specimen of fossil; from Ohio.

Marnock, G. W. Specimens of toads; from Texas.

Marshall, George. Specimens of birds; from Maryland.

Marvin Brothers and Bartlett, Portsmouth, N. H. Five cases of samples of cod-liver oil.

Matthews, Charles. Specimen of caterpillar; from Arkansas.

Mayo, Henry, & Co., Boston, Mass. A large number of samples of the various kinds of preserved fishes.

McCarthey, Capt. John F. Specimen of bat-fish (*Malthe cubifrons*); from Florida.

McChesney, Charles E. Two birds' skins (*Passerculus, Melospiza*); from Dakota.

McCormick & Connable. Specimens of rock-sturgeon and whitefish; from Lake Michigan.

McDonald, Col. Marshall. Eight boxes of alcoholic specimens of fishes, &c.; from the South Atlantic States.

McEwen, John B. Can of alcoholic specimens of fishes; from Tennessee.

McGraw, James C. Mineral; from West Virginia.

McLean, Rev. J. P. Specimens of Indian relics; from Ohio and Indiana.

McMenamin & Co., Hampton, Va. Case of canned crabs.

Mazyck, Lieut. J. Two shells; from South Carolina.

Mazyck, W. St. J. Specimens of sponges, corals, and shells; from South Carolina.

Medsen, Peter (through Prof. D. S. Jordan). Two tanks of fishes; from Utah.

Meigs, M. C., Quartermaster-General, U. S. A. Plaster molds of medallions of Washington, Lincoln, Chase, and Seward.

Mell, P. H., jr. Insect and shells; from Alabama.

Merchant, George. Models of seine-needles and pins.

Merman, Lyman A. Samples of herring oil and specimens of herring.

Merriam, Joseph W., United States Consul, Iquique, Peru. Samples of Peruvian guano.

Merrill, Dr. J. C., U. S. A. Specimens of mammals, fishes, and birds; from Montana.

Metcalf, M. Albino raccoon and stone hatchet; from Battle Creek, Michigan.

Metcalfe, James K. Specimens of insects; from New Mexico.

Metz, Dr. Charles L. Box of Indian implements; from Ohio.

Mexico, National Museum of. G. Mendoza, Director. Cast of a sacrificial stone.

Milam, B. C. Frankfort fishing-reel (purchased).

Miller, Frank. Box of fossils; from Texas.

Miller, Mrs. J. E. Specimens of rocks; from New York.

Miller, M. A. Box of Indian relics; from Virginia.

Mims, E. J. Specimens of plants; from South Carolina.

Mintzer, W. A., P. A. Engineer, U. S. N. Alcoholic specimen of fish; from Delaware.

Mobley, G. B. Specimens of German carp; from Alabama.

Money, Hon. H. D. Specimens of ores; from Mississppi.

Moore, C. R. Specimens of Indian implements; from Virginia.

Moore, John. Specimens of rock conglomerate; from Arkansas.

Moore, N. B. Lamprey eel and feathers of wild turkey.

Moran, Dr. George H., U. S. A. One living and one stuffed specimen of Gila monster; from Arizona.

Morrison, J. R. D. Living moth; from Washington.

Mueller, Dr. R. Two Indian relics; from Indiana.

Muis, W. S. Box of shells; from Utah.

Mundt, A. H. Box of fossil plants; from Illinois.

Myers, Justin M. T. Box of fossils; from Ohio.

Nelson, E. W. Seventeen boxes of general natural history and ethnological specimens; from Alaska.

Nelson, John. Box of fishermen's clothing.

Nelson, Robert. Two living garter snakes (*Eutænia*); from District of Columbia.

Neve, E. Three silver Indian (?) relics; from Florida.

Newsome, David. Specimen of ore; from Oregon.

Newton, Edward. Living specimen of yellow boa (*Chilobothrus inornatus*) and box of bird skins; from Jamaica.

Nichols, Mrs. E. J. Specimens of ores; from Texas.

Nichols, Dr. H. A. A. Two boxes of birds and alcoholic specimens of natural history; from Dominica.

Niles, Frank G. Specimen of *Crilla*; from Connecticut.

Niles, J. Nest and eggs of swallow, and lizard; from Pennsylvania.

Nixon, J. S. Specimens of birds and mole (*Condylura*); from Pennsylvania.

Nodor, Dr. O. D. Photographs of tusks of *Bison latifrons*.

North, Rev. J. B. Specimens of minerals; from Virginia.

Nye, Millard, jr. Box of Indian relics; from Massachusetts.

Ober, A. K. Stone implement; from Massachusetts.

Ober, F. A. A large collection of natural history specimens, principally birds; from the West Indies.

Ogilby, J. Douglas. A collection of birds' skins; from Texas.

Orcutt, C. R. A small box of shells; from California.

Osborn, A. (*through T. B. Ferguson*). Jar of alcoholic specimens of fishes; from the Potomac River.

Osborn & Vail. Two specimens of horse-fish (*Vomer setipinnis*); from New Jersey.

Palmer, William. Specimens of birds and reptiles; from Virginia and Maryland.

Parker, H. A. Specimen of cup-stone; from Illinois.

Parker, Joel C. Fish-hatching box, used at Grand Rapids, Mich.

Parkhurst, C. D. Specimen of coal; from Colorado.

Patterson, H. N. Box of water-plants (*Nymphæa tuberosa*); from Illinois.

Patterson, S. Specimens of minerals; from Virginia.

Paxson, S. W. Specimens of minerals; from New Mexico.

Peckham, R. W. Specimen of smooth puffer (*Tetrodon lævigatus*); from Connecticut.

Pellet, E. P. Box of minerals; from the United States of Colombia.

Perry, J. W. Specimens of crystals; from Florida.

Perry, Ralph. Indian mortar; from Indiana.

Philadelphia, Pa., Zoological Society of. A number of skulls and skeletons of monkeys.

Pierce, Milton P. Fragments of Indian pottery; from New Jersey.

Pirz, Anthony. Two boxes of stalactites and specimens of Proteus anguinus; from Adelburg Grotto, in Carniola.

Plant, J. C. Collection of minerals and Indian relics; from Georgia.

Plumacher, E. H., United States Consul, Maracaibo, Venezuela. Collection of butterflies; from Venezuela.

Poey, Prof. Felipe. Nine boxes of living reptiles and two boxes of alcoholic specimens of fishes; from Cuba.

Polkinhorn, H. Living tree-toad (*Hyla versicolor*); from Washington, D. C.

Polleys, W. H., United States Consul, Barbadoes, W. I. (*through William Wood*). Specimens of septaria and infusorial earths; from the West Indies.

Powel, Samuel. Scale of tarpum (*Megalops thrissoides*); from Rhode Island.

Powell, J. W., Director Ethnological Bureau, Smithsonian Institution. Sixty-four boxes of ethnological specimens; from Arizona and New Mexico; collected by James Stevenson and Frank H. Cushing.

Prentiss, Dr. D. W. Specimens of ants.

Prindle, Frank. Specimens of (*Diadophis punctatus*); from Virginia.

Proctor, J. O. Model of fishing-schooner Mary Odell, of Gloucester, Mass. (Purchased.)

Prosser, William Q. F. Specimen of *Octopus*; from Seattle Bay, Washington Territory.

Prouty, C. R. Collector of Customs, Indianola, Tex. Mounted specimen of crane.

Pryer, Jasper, New York, N. Y. Samples of fish oils.

Pumpelly, Prof. R. Eighteen packages of minerals; from various localities in the United States.

Pusey, S. N. Specimens of stickleback (*Gasterosteus aculeatus*); from Delaware.

Ramsey, Alexander, Secretary of War. Two boxes of minerals; from Minnesota.

Ramsey, N. A. Specimen of clay; from Durham, N. C.

Rattan, V. Specimens of mosses and lichens; from California.

Redding, B. B. Bulbs of *Camassia esculenta*; from California.

Reid, George W. Specimens of minerals and Indian relics; from Pennsylvania.

Remington, Cyrus K. Buckskin purse, from Pike's Peak, Colorado.

Reynolds, Dr. Elmer E. Specimens of minerals and Indian relics; from Virginia.

Richard, John H. Box of living turtles; from Pennsylvania.

Richards, A. H. Specimen of mineral; from California.

Richmond, Va., College of. Specimen of *Tuckahoe* (Indian bread).

Richter, Dr. Theodore. Specimens of minerals; from Freiburg.

Ridgway, Robert. Specimens of birds' skins; from Illinois, Virginia, and California.

Ridgway, Robert, and Henry Marshall. A large collection of birds' skins; from Cobb's Island and vicinity.

Rives, J. H. Specimens of rocks; from Virginia.

Robertson, Dr. W. B. Head of brook trout (*Salvelinus fontinalis*); from the James River, Virginia.

Robey, Rufus. Specimens of beetles; from Maryland.

Robinson, C., jr. Two snakes (*Tropedonotus sipedon* and *Ophibolus doliatus*); from the District of Columbia.

Rogers, John S. Specimens of glue, isinglass, &c.

Romeyn, H., U. S. A. Specimens of sea-horse (*Hippocampus*); from Virginia.

Rosamond, W. B. Specimen of mineral; from Ohio.

Rounds, Ralph W. Specimens of Maine flora.

Rowlet, F. Indian relic; from New York (lent for casting).

Ruby, Charles, private, U. S. A. Fossil shells and bones, one pair of elk-horns and one pair of deer-horns; from Fort Laramie, W. T.

Rusby, S. H. Indian dish; from New Mexico.

Russell, Thomas J. Box of shells and broken pottery; from Texas.

Samford, Hon. W. J. Specimen of ore.

Sanborn, J. K. Specimens of conglomerate.

Saunders, Col. John S. Living catfish; from Chesapeake Bay.

Sayre, Dr. L. A. Carved stone mask; from New York (lent for casting).

Schacht & Fruchknecht, Sandusky, Ohio. Samples of caviar, isinglass, and fish oils.

Schlegel, Jacob. Specimens of feldspar; from Virginia.

Schneck, Dr. J. Specimens of living tortoises (*Pseudemys elegans*); from Illinois.

Schonborn, H. F. Two eggs of dove (*Streptopelia risoria*).

Scott, David W. Specimens of birds' skins.

Sebring, James E., jr. "Bull-dog" Catlinite pipe; made by the Sioux Indians of Dakota (purchased).

Sellman, Henry G., Eastport, Me. Six boxes of "sardines."

Sewall, C. A., Acting Assistant Surgeon, U. S. A. Specimens of insects; from New Mexico.

Shaw, B. F. Model of fishway used at Anamosa, Iowa.

Sheldon, D. S. Box of fossils and a living snake; from Iowa.

Sheperd, R. T. Box of alcoholic reptiles; from Ohio.

Sidman, George D. Specimens of minerals; from South Africa.

Simmons, C. A. Two fossil shark's teeth; from Florida.

Simmons, Newton. Eighteen arrow-heads, from Maryland; and a specimen of centipede, from Texas.

Slater, J. H., U. S. Senate. Specimen of coal; from Oregon.

Slaughter, John B. Specimens of minerals; from Texas.

Small, Edgar A. Specimens of birds' eggs.

Small, E. E. Embryo porpoise; from Provincetown, Mass.

Smiley, C. W. Specimen of moth.

Smith, Mrs. Emma (through Maj. J. W. Powell). Specimens of Indian wedding cake; Cattaraugus Reservation, New York.

Smith, Charles B. Six arrow-heads; from Maryland.

Smith, Charles J. Specimens of smelts (*Osmerus pacificus*); from Oregon.

Smith, Everett. Model of fishway used on the Penobscot River (purchased) and specimens of smelts (*Osmerus mordax*).

Smith, Prof. H. L. Century of microscopic slides.

Smith, W. A. Specimens of black crystals; from Texas.

Smyth, John H., United States Minister Resident to Liberia. Specimens of African handiwork; from Liberia.

Snow, A. L. Specimen of zinc ore; from Tennessee.

Snow, Franklin, & Co., Boston, Mass. A large collection of preserved fish of various kinds.

Southwick, J. M. K. Specimens of mackerel (*Scomber*); from Newport, R. I.

Spangler, George. Specimen of water-dog (*Necturus lateralis*); from Indiana.

Sperry, Edward H. Specimen of hare (*Lagomys princeps*); from Colorado.

Sperry, L. A. Spear-point; from Illinois.

Spinner, F. E. Box of fossil shells; from Florida.

Spray, S. J. Specimen of weasel (*Putorius vulgaris*); from Colorado.

Springer, Hon. William. Specimens of minerals.

Stabler, James P. Six hawks and three owls and a living blacksnake (*Bascanion constrictor*); from Maryland.

Star Mica Company, Pensacola, Fla. One box of minerals.

Stearns, Silas. Five boxes of specimens of fishes, &c.; from Florida.

Stephens, Hon. A. H. Box of minerals; from Georgia.

Sterling J. E. N. Specimens of fish; from Maryland.

Stevenson, James. Box of pottery; from New Mexico; and a specimen of Florida alligator.

Stevenson, James, and Mr. Russell. Six boxes of fossils and rocks; collected in New Mexico. (See Powell.)

Stimpson, William G. Spider and nest.

Stone, Livingston. Three boxes of fossils and a keg of alcoholic salmon skins; from California.

Stout, W. C. Insect; from Arkansas.

Swan, James G. Three boxes specimens of fishes, specimens of dried fish put up by Indians, and a carved Indian club; from Washington Territory and Vancouver's Island

Sweeny, Dr. R. O. Specimens of siscowet and trout; from Lake Superior.

Sweet, Charles D. Specimens of insects; from Florida.

Sweezey, Goodwin D. Specimen of mole (*Blarina talpoides*); from Massachusetts.

Sweitzer, Lieut. J. B., U. S. A. Eagle-ray; from Fort Brown, Texas.

Symmes, F. M. Box of stone implements; from Indiana.

Talbot, Walter M. Specimens of minerals; from Maryland.

Taylor, Fred. W. Specimens of minerals and ores; from various localities.

Taylor, Dr. H. W., U. S. A. Horned-toad (*Phrynosoma*); from the Indian Territory.

Taylor, W. G. Specimen of banded rudder-fish; from the Potomac River.

Taylor, W. J. Four boxes of specimens of natural history; from Georgia.

Thomas, W. G. Specimen of beetle (*Dynastes hercules*); from North Carolina.

Thompson, C. W. Specimens of coal; from Dakota.

Thompson, Daniel. Two insects from cane-plant; from Louisiana.

Thomson, J. H., New Bedford, Mass. Barrel of whale-boat fittings.

Thurber, E. W. Specimens of minerals; from Rhode Island.

Tichkematse (Indian). Specimens of birds and antlers of deer; from the Indian Territory.

Tillson, Perry. Cast of Indian relic; from Ohio.

Trabing Brothers. Specimen of mineral; from Wyoming.

Tracy, C. C. Specimens of minerals; from Nevada.

Traill, C. H. Specimens of shells (*Rhynchonella*); from New Zealand.

Trezevant, Dr. G. T. (through E. E. Jackson). Specimens of fossil teeth of sharks; from the phosphate beds of South Carolina.

Tripp, T. M. Bird skin (*Nephœcetes niger*); from Colorado.

True, F. W. Two stone implements; from Virginia.

Tuerpe, Albert. Specimens of sirens; from Texas.

Tuggle, W. O. Two bones of fossil elephant; from Texas.

Ulrich, E. O. Box of fossils; from Arkansas.

Union Oyster Company, Baltimore, Md. Four boxes of canned oysters.

Valentine, Gabriel. Specimens of minerals; from Pennsylvania.

Valentine, Mann S. Sample of extract of oyster.

Van Camp, Dr. Specimen of fish; from the Fiji Islands.

Vene, Leroy. Water-worn rock; from Virginia.

Wadham, J. E. Specimens of seeds and minerals; from California.

Wagg, Dr. James. Specimen of mineral, from North Carolina.

Walker, S. T. A collection of birds' skins, Indian relics, and shells; from Florida.

Walker, T. G. Specimens of peat; from New Jersey.

Wallace, John. Stuffed skin of raccoon (*Procyon lotor*).

Wallis, R. A. Specimen of pipe-fish (*Syngnathus peckianus*); from Maryland.

Ward, Prof. H. A. A bottle of fishes; from Ceylon and Borneo.

Washington, D. C.:

Interior Department:

Box of plants, seeds, and woods, &c., collected by *S. Hayes.* Specimens of minerals; from California.

Soils collected between Sierra Nevada and City Rocks, by *F. A. Bishop.*

Census Office. (See under the names of *Edward Atkinson* and *W. M. Chmeuret.*)

General Land Office. (See under names of *Surveyor-General John Wasson* and *Special Agent James Bell.*

Geological Survey, Clarence King, United States Geologist. (See under the names of *G. K. Gilbert* and *R. Pumpelly.*)

Office of Indian Affairs:

Two boxes of Indian relics from graves at Forestville, N. Y. *D. Sherman, Agent,* collector.

United States Commission of Fish and Fisheries. (*Prof. Spencer F. Baird, Commissioner.*) About 225 boxes of zoological collections from the Atlantic and Pacific coasts, made by *Prof. A. E. Verrill, Richard Rathbun, Charles H. Gilbert, G. Brown Goode, A. Howard Clark,* and *D. S. Jordan;* also, a number of models of fishing vessels and implements. (See also under the names of *Charles G. Atkins, Tarleton H. Bean, H. C. Chester, A. H. Clark, F. N. Clark, J. W. Collins, W. H. Dall, R E. Earll, T. B. Ferguson, Charles H. Gilbert, G. Brown Goode, William Hamlen, E. Ingersoll, D. S. Jordan, M. McDonald, John S. Saunders, Newton Simmons, Charles W. Smiley, Livingston Stone,* and *James G. Swan.*) Specimens of marine natural history have besides been received from the following captains and crews of fishing vessels sailing principally from Gloucester, Mass.:

Washington, D. C.—Continued.

United States Commission of Fish and Fisheries—Continued.

Abbe, W. A. Specimens of young menhaden; from Promised Land, N. Y.

Anderson, Capt. Charles F., and crew of schooner Alice G. Wonson. Specimens of sponges (*Chalina*), corals (*Primnoa, Paragorgia*, &c.), shells, sea-urchins, crabs, eels (*Murænoides, Synaphobranchus*), fishes (*Centroscyllium*), &c.; from George's Bank.

Andrews, B. W., Benjamin Marshall, and others, of Rockport. Pair of iron rollers used in 1840 at Rockport, Mass., in the manufacture of isinglass from fish sounds.

Ardendale, Edward, schooner Josephine. Specimens of fishes (*Hemitripterus, Prionotus*, and *Cryptacanthodes*), crabs, star-fishes, and other marine invertebrates; from off Cape Sable, Pollock's Rips, and Ipswich Bay.

Bishop, John H. Models of schooners Emma S. Osier and John W. Smart.

Borson, William. Branch of sea coral (*Primnoa reseda*), with barnacles.

Brown, Edward O., schooner Albert A. Harding. Specimens of fishes, shrimps, and stomachs of mackerel; taken along coasts of Maine and Massachusetts.

Burnham, Jeremiah. Two models of fishing vessels (purchased).

Burnham, Willard R. Two models of fishing vessels (purchased).

Burns, Thomas. Young mackerel and sponge (*Halichondria*); from Seal Island Ground.

Campbell, Capt. David, and crew of schooner Admiral. Specimens of corals (*Alcyonium*), sponges (*Polymastia*), barnacles (*Balanus*), star-fishes, sea feathers, &c.; from Grand Bank.

Carroll, Capt. Frank, and crew of schooner Polar Wave. Specimens of fishes (*Scopelus, Petromyzon*, and *Synaphobranchus*), corals (*Flabellum, Acanella*), sponges, &c.; from Saint Peter's Bank and Banquereau.

Cavangher, Lawrence, schooner Bellerophon. Specimens of fishes (*Sebastes, Synaphobranchus*), sponges (*Polymastia*), and corals (*Primnoa*); from George's Bank.

Colby, Charles. Specimens of shells, sea-worms, star-fishes, &c.; from off Thatcher's Island.

Colby, Henry. Sea-gurnard (*Prionotus carolinus*); Gloucester Harbor.

Collins, Capt., D. E., and crew of schooner Gussie Blaisdell. Specimens of star-fishes (*Asterias, Solaster*), corals, shells, ascidians, &c.; from the Grand Banks.

Collins, John, and crew of schooner Albert H. Harding. Young dog-fish with sack attached, and specimens of mackerel food; from off Chatham and Noman's Land.

Conly, John. Specimens of fish (*Auxis*); from Gloucester Harbor.

Corliss, Capt. William, and crew of schooner Laughing Water. Specimens of fishes (*Cyclopterus, Petromyzon, Murænoides*), shells, star-fishes, &c.; from George's Bank.

Cousens, Captain, and crew of schooner Mist. Young skate, eggs of gasteropod, finger-sponge, hydroids, shells, &c.; from the Western Bank.

Crew, Capt. Charles, and crew of schooner Isaac A. Chapman. Specimens of fishes (*Myxine, Chirostoma, Gadus, Synaphobranchus, Chimæra, Petromyzon*), &c., corals (*Alcyonium, Acanthogorgia, Anthomastus, Keratoisis, Acanella*, &c.), sponges (*Polymastia, Halichondria, Phabellia*), ascidians, sea cauliflowers, hydroids, anemones, &c.; from the Green, Saint Peter's, and Grand Banks and Banquereau.

Critchett, Captain, and crew of schooner Flash. Specimens of spiders (*Nymphon*), sponges (*Polymastia*), horseshoe crabs (*Limulus*), star-fishes, &c.; from George's Bank.

Washington, D. C.—Continued.

United States Commission of Fish and Fisheries—Continued.

Crittenden, A. R. Fossiliferous bowlders from Cape Cod, and samples of trawl-rollers used in Gloucester fisheries.

Cuddy, Captain, and crew of schooner Joseph O. Specimens of mussel-shells, barnacles, and fishes; from George's Bank.

Curley, Hugh, schooner Legal Tender. Crawfish, from the Providence River; and finger-sponge (*Chalina*); from the South Channel.

Daniels, Captain, and crew of schooner David M. Hilton. Specimens of scallops, barnacles, sponges, and hydroids; from George's Bank.

Dempsey, Capt. William, schooner Clara F. Friend. Specimens of fishes (*Zoarces, Mallotus, Myxine, Petromyzon*), corals, squids, shrimps, sponges, &c.; from George's and Brown's Banks.

Dixon, Capt., and crew of schooner Flora Temple. Specimens of spider-crab (*Lithodes*), star-fish (*Hippasteria*), and sponge (*Chalina*); from Middle Bank.

Douglass, Albert. Specimens of squeteage and scuppaug; from Magnolia, Mass.

Douglass, Thomas. Specimens of fishes (*Menticirrus, Centropristis*) and squid; from Magnolia, Mass.

Dower, Augustus, schooner Victor. Specimens of shells, worms, squids, crabs, &c.; from the Grand Banks.

Fitch, Captain, and crew of schooner Herbert M. Rogers. Specimens of corals (*Celleporaria, Escharopsis, Alcyonium*), ascidians, sea-corn, &c.; from the Grand Banks.

Fowles, Frank, schooner Young Sultan. Specimens of star-fishes (*Asterias, Ophiopholis, Ctenodiscus*), whelks, sea-anemones, &c.; off Cape Ann, Massachusetts.

Fowles, J. Frank, steamer Geo. H. Bradley. Specimens of menhaden and menhaden food and spawn; also crabs, shell, sponges, &c.; from various places along Long Island Sound.

Geary, Capt. John, schooner Sunshine. Finger-sponge (*Chalina*), swordfish-sucker (*Remora*) and parasites; from Ipswich Bay and coast of Maine.

Getchell, Capt. John Q., and crew of schooner Otis P. Lord. Specimens of fishes (*Triglops, Gadus, Sebastes, Petromyzon, Murænoides, Prionotus, Achirus*), sponges (*Polymastia, Chalina*), corals (*Alcyonium*), tunicates, bryozoans, barnacles, crabs, &c.; from George's Bank.

Gibbs, Captain, and crew of schooner Oceanus. Scarlet-cushion star-fish; from off Cape Negro, N. S.

Gill, Capt. Israel, schoonerEmma. Piece of nipple-sponge (*Polymastia*), from off Sankaty Head; and back-bone of pig-shark, off Gloucester Harbor.

Gilpatrick, Capt. Briggs, and crew of schooner Gatherer. Specimens of fishes (*Synaphobranchus, Scopelus, Alepidosaurus, Petromyzon, Sebastes, Myxine*), sea-feathers, sponges, star-fishes, &c.; from the Grand Banks.

Gourville, Capt. J., and crew of schooner Rebecca Bartlett. Specimens of fishes (*Sebastes, Triglops, Murænoides, Petromyzon*), sponges (*Chalina*), bryozoans, hydroids, &c.; from George's Bank.

Greenleaf, Capt. N., and crew of schooner Grace L. Fears. Specimens of fishes (*Scopelus, Lycodes*) and skate's egg; from Green Bank.

Guthrie, Captain, and crew of schooner Mary Brown. Lump-fish (*Cyclopterus lumpus*), weighing ten pounds; caught off Thatcher's Island.

Hall, Captain, and crew of schooner Clytie. Specimens of eels (*Murænoides, Petromyzon*), star-fishes, mussels, holothurians, crabs, &c.; from George's Bank.

Washington, D. C.—Continued.

United States Commission of Fish and Fisheries—Continued.

Harrington, John. Specimens of star-fishes, shells, shrimps, anemones, &c.; from George's Bank.

Harrington, John, schooner Otis P. Lord. Specimens of fishes, sponges, anemones, star-fishes, hydroids, shrimps, &c.; from George's Bank.

Hodgdon, Capt. Thomas, and crew of schooner Bessie W. Somes. Specimens of fish (*Chiasmodes niger*, *Sebastes*, *Simenchelys*, *Macrurus*), corals (*Alcyonium*, *Acanthogorgia*, *Keratoisis*, *Anthothela*), &c.; from the Grand Banks.

Hodgdon, Captain, and crew of schooner Proctor Brothers. Specimens of sea-feathers (*Pennatula*, *Balticina*), sponges (*Polymastia*, *Phabellia*), sea-worms, &c.; from Grand Banks.

Hooper, R. A., bark Silas Fisk. A large mackerel (*Scomber* sp.); from off the coast of Chili.

Hurlburt, Robert, schooner Star of the East. Large mussel-shell with sponge (*Chalina*); from George's Bank.

Hurlburt, Robert, schooner Barracuta. Small octopus; from Brown's Bank.

Hurlburt, Robert. Specimens of yellow perch, horned pout, red fin, &c.; from off Yarmouth, N. S.

Jacobs, Capt. Sol, schooner Sarah M. Jacobs. Specimens of fish (*Scomberesox*, *Cyclopterus*, *Poronotus*, *Gasterosteus*, and *Scomber*); from off Cape Cod.

Jacobs, Capt. Sol, schooner Edward E. Webster. Specimens of fish (*Auxis*, *Poronotus*), sponge, sword-fish parasites, &c.; from off Block Island.

Jellow, John, schooner Frederick Gerring. Perforated stone; from south coast of Newfoundland.

Jellow, John, schooner Henry Friend. Part of a small anchor covered with bryozoans and hydroids; from George's Bank.

Jewett, Silas, schooner Phantom. Specimens of star-fish (*Ophioglypha Sarsii*) and egg capsules (*Sycotypus*); from Ipswich Bay and Providence River.

Johnson, Capt. George A., schooner Augusta H. Johnson. Specimens of fish (*Macrurus*, *Centroscyllium*, *Petromyzon*, *Simenchelys*, *Sebastes*, *Synaphobranchus*), corals (*Flabellum*), ascidians, crabs, star-fishes, &c.; from the Grand and Saint Peter's Banks.

Johnson, Capt. Levi, and crew of schooner Lizzie. Pug-nosed eels (*Simenchelys*) and star-fishes (*Asterias*); from Grand Banks.

Johnson, Capt. Otto, and crew of schooner Magic. Specimens of fish (*Murænoides*, *Brosmius*), shells, hydroids, barnacles, &c.; from George's Bank.

Kill, Capt. William, and crew of schooner Eureka. Young moon-fish (*Parephippus quadratus*); from off Seguin, Me.

Knight, Capt. T. H., schooner Ocean King. Specimens of star-fishes (*Ophioglypha*, *Hippasteria*, *Ctenodiscus*, *Asterias*, *Crossaster*); corals (*Alcyonium*), crabs, clams, ascidians, &c.; from Grand Banks.

Landry, Simeon. Rock with Chalina sponge; from off Sankaty Head.

Lawson, Capt. Charles, and crew of schooner Herman Babson. Specimens of crustaceans, molusca, ascidians, tunicates, star-fishes, &c.; from the Grand Banks.

Lawson, Captain, and crew of schooner Henry Stanbury. Stone covered with barnacles (*Balanus*); from George's Bank.

Lee, Capt. Charles, schooner Orient. Cramp-fish (*Torpedo occidentalis*); from Ipswich Bay.

Lowry, Captain, and crew of schooner Aberdeen. Specimens of fish (*Triglops*), shells (*Pecten*, *Modiola*) star-fishes, finger-sponge, hydroids, &c.; from George's Bank.

Washington, D. C.—Continued.

United States Commission of Fish and Fisheries—Continued.

Lurvey, William, Rock-gurnard (*Prionotus carolinus*) from Ipswich Bay.

McAskell, Capt. Neil, and crew of schooner Lizzie. Specimens of fish (*Macrurus, Anarrhichas, Platysomatichthys, Myxine, Scopelus, Centroscyllium Sebastes, Petromyzon*), corals (*Alcyonuim Primnoa*), sponges (*Polymastia, Phakellia, Cladorhiza*), star-fishes, ascidians, &c., from the Grand Banks.

McCurdy, Alex. Sample of double-edged throating-knife, made at Gloucester, Mass., for use in fisheries at Alaska.

McDonald, James, schooner E. B. Phillips. Specimen of spiny spider-crab (*Lithodes maia*); from Jeffrey's Ledge.

McDonald, Capt. Jerome, and crew of schooner Solar Wave. Specimens of fishes (*Coryphænoides, Myxine*), devil-fish (*Octopus*), sponges (*Cladorhiza*), sea-feathers, &c.; from the Grand Banks.

McDonough, Hervey, schooner Finance. Young codfish (*Gadus*), star-fish (*Asterias*), and barnacles; from off Cape Negro, N. S.

McGraw, James. Sea-mouse (*Aphrodite*), from off Eastern Point; and mussel-shell covered with eggs of gasteropod; from George's Bank.

McIntosh, Captain, and crew of schooner Paul Revere. Holothurians, shrimps, sponges, &c.; from Jeffrey's Ledge.

McIntyre, Captain, and crew of schooner Paul Rerere. Crinoids, parasites from codfish, and ovaries of shark; from George's Bank.

McKenzie, Capt. Andrew, and crew of schooner Bellerophon. Specimens of fish (*Aspidophoroides, Sebastes*), algæ, star-fish, crabs; from off Nova Scotia and Newfoundland.

McKinnon, Capt. Daniel, and crew of schooner Mary F. Chisholm. Specimens of fishes (*Simenchelys, Petromyzon, Haloporphyrus, Centroscypllium, Synaphobranchus, Scopelus*), corals (*Flabellum, Acanthogorgia, Keratoisis*), crabs, &c.; from the Grand Banks.

McKinnon, Capt. John, and crew of schooner Mystic. Specimens of fishes (*Poronotus, Sebastes, Muraenoides, Hippoglossoides*), shells, star-fishes (*Asterias, Hippasteria,*) sea-roses, corals, &c.; from the George's and Grand Banks.

Mahlman, David. Specimes of fishes (*Seriola* and *Menticirrus*); from off Eastern Point.

Marble, Frank. Portion of codfish's backbone with excrescence.

Markuson, Capt. Kurd, and crew of schooner Notice. Specimens of fishes (*Mallotus, Apeltes, Sebastes,* &c.), corals (*Acanella, Alcyonium, Acanthogorgia*), star-fishes, sea-feathers (*Pennatula, Balticina*), shells, &c.; from the Grand Bank.

Martin, Capt. Charles, and crew of schooner Martha C. Specimens of fishes (*Mallotus, Scomberesox, Clupea*), star-fishes (*Crassaster, Solaster*), shells, sea-anemones, sponges, &c.; from George's Bank.

Martin, Capt. George H., and crew of schooner Northern Eagle. Specimens of star-fishes (*Hippasteria*), fishes (*Murænoides, Scomber, Tautogolabrus*), corals (*Primnoa*), &c.; from the Grand Bank, Ipswich Bay, and the coast of Maine.

Martin, Capt. S. J. Specimens of fishes (*Lamna, Anarrhichas, Gadus, Tautogolabrus,* &c.); from Gloucester Harbor.

Merchant, George, schooner Hattie B. West. Variety of mackerel; from the coast of Maine.

Merchant, Philip. Branch of gold-banded nest coral (*Keratoisis ornata*); from Banquereau.

Merchant, Philip, schooner Everett Steele. Specimens of fishes (*Petromyzon, Phycis, Chirostoma*), shells, hydroids, crabs (*Cancer,*&c.); from the George's Banks.

Washington, D. C.—Continued.

United States Commission of Fish and Fisheries—Continued.

Merchant, Capt. Philip, and crew of schooner Marion. Specimens of fishes (*Chimæra, Anarrhichas, Haloporphyrus, Synaphobranchus*), sea-rose (*Urticina*), sponge (*Polymastia*), corals (*Acanella*), &c.; from the Grand Bank.

Merchant, Capt. Philip, schooner Wachusett. Brisinga star-fish, shark's eggs, and nipple-sponge; off Banquereau.

Mitchell, Manuel D., schooner Sultana. Specimens of fishes (*Achirus, Nemichthys*), star-fishes (*Solaster, Astrophyton, Lophasteria*), crabs (*Cancer, Hyas, Geryon*), shrimps, holothurians, &c.; from George's Bank.

Morris, Captain, and crew of schooner Frederick Gerring. Perforated stones and lamp shells; from off Saint Peter's Bank.

Morrissey, Capt. James D., and crew of schooner Plymouth Rock. Specimens of fishes (*Myxine, Zoarces, Synaphobranchus, Simenchelys, Petromyzon, Centroscyllium, Macrurus Fabricii,* and *M. Bairdii, Sebastes, Scopelus, Centroscymnus*), star-fishes (*Ophiopholis, Ctenodiscus*), sea-feathers (*Pennatula, Balticina*), corals (*Flabellum, Acanthagorgia, Acanella, Alcyonium*), marine worms, anemones, &c.; from the Grand and Green Banks.

Morrison, Capt. R. and crew of schooner Laura Nelson. Specimens of fishes (*Scomberesox, Myxine*), corals, sponges, sea-feathers, &c.; from Grand and Artimon Banks.

Murphy, Capt. Charles, and crew of schooner Alice M. Williams. Specimens of fishes *Myxine, Macrurus, Scopelus, Mallotus*), corals (*Primnoa, Acanella, Paragorgia, Keratoisis, Acanthomastus*), sponges (*Polymastia, Phakellia, Cladorhiza*), sea-feathers (*Pennatula, Balticina*), star-fishes, &c.; from Saint Peter's, Grand, and Banquereau Banks.

Murphy, Captain, and crew of schooner Proctor Brothers. Specimens of sponges (*Polymastia, Cladorhiza*), sea-rose (*Urticina*), and sea-feathers (*Virgularia*); from Saint Peter's Bank.

Nason, Captain, schooner William A. Pew. Specimens of fishes (*Lophius, Myxine*), star-fishes (*Crossaster, Ophiopholis*), shells, bryozoons, &c.; from George's Bank.

Neil, Captain, and crew of schooner Alfred Walen. Bunch of tumorous substance taken from stomach of codfish on George's Bank.

Nelson, Capt. Anderson, schooner Starry Flag. Large perforated rock; from George's Bank.

Newbury, Captain, and crew of schooner Barracouta. Great scallop (*Pecten tenuicostatus*) with barnacles (*Balanus*) attached; from George's Bank.

O'Brien, Capt. Daniel, and crew of schooner Guy Cunningham. Specimens of fishes (*Macrurus, Centroscyllium, Synaphobranchus, Myxine*), sponges (*Cladorhiza, Phakellia*), corals (*Acanella, Acanthogorgia, Paragorgia, Paramuricea, Flabellum*), sea-feathers (*Balticina, Pennatula*), star-fishes (*Asterias, Ctenodiscus*), &c.; from Grand Banks.

Olsen, Capt. George, and crew of schooner Procter Brothers. Pilot-fish, sponges (*Cladorhiza Phakellia, Polymastia*), sea-feathers, shells, anemones, &c.; from the various banks off Newfoundland.

Olsen, Capt. Thomas, and crew of schooner Epes Tarr. Specimens of fishes (*Anarrhichas, Myxine, Scopelus, Centroscyllium, Synaphobranchus, Petromyzon*), corals (*Paragorgia, Primnoa, Alcyonium, Anthomastus*), sponges (*Phakellia, Cladorhiza*), devil-fishes, anemones, crinoids, &c.; from the Grand and Saint Peter's Banks.

Osier, Capt. David A., schooner Breeze. Large sea-lamprey (*Petromyzon marinus*); from Ipswich Bay.

Pearce, Fred. Base of coral (*Primnoa*), with lamp shells and brittle star-fish; from Banquereau.

Washington, D. C.—Continued.

United States Commission of Fish and Fisheries—Continued.

Perrel, William H., schooner Joseph O. Specimens of sponges, star-fishes, mussels, &c.; from George's and Brown's Banks.

Pettingell & Cunningham, Gloucester. Whale's rib bone.

Poland, Daniel. Three models of fishing-vessels.

Radcliffe, Captain, Young thresher shark (*Alopias vulpes*); from off Eastern Point.

Riggs, Capt. Joshua, schooner Fitz J. Babson. Specimens of frigate mackerel (*Auxis*); from off Block Island.

Rowe, John. Calcareous rock; from George's Bank.

Ryan, Capt. J., and crew of schooner David A. Story. Specimens of fishes (*Myxine, Macrurus, Synaphobranchus, Petromyzon, Centroscyllium, Scopelus*), sponges (*Halichondria, Phakellia*), corals (*Alcyonium, Paragorgia*), hydroids, sea-roses, ascidians, shells, sea-mice, &c.; from the Grand Bank.

Schooner Adelia Hartwell, captain and crew of. Two large honey comb rocks; from George's Bank.

Schooner Enola C., captain and crew of. Horse mussels (*Modiola*) with barnacles (*Balanus*) attached; from George's Bank.

Schooner Josephine, of Rockport, captain and crew. Ling or mutton-fish; from off Chatham, Mass.

Schooner Mary E. Daniels, captain and crew of. Spiny lump-fish (*Eumicrotremus spinosus*), bryozan coral (*Escharopsis rosacea*) and eggs of gasteropod; from the Grand Banks.

Schooner Northern Star, captain and crew of. Large monk-fish (*Lophius americanus*); from Western Bank.

Schooner William Parsons, 2d. Specimen of balæna; from the Grand Banks.

Scott, George W., schooner Clytie. Specimen of fishes (*Scomber, Gadus, Petromyzon*), crabs (*Hyas*), shells, hydroids, &c.; from Brown's Bank.

Skarin, Herman. Barnacles (*Balanus*) and chalina sponge; from Brown's Bank.

Smith, Capt. Joseph, schooner Wm. M. Gaffney. Sea-horse (*Hippocampus*); from off Block Island.

Smith, Capt. Robert, schooner Volunteer. Specimen of mackerel; from off Seguin, Maine.

Spurr, Capt. Alfred, and crew of schooner John F. Wonson. Specimens of sea feathers, corals, tunicates, &c.; from George's Bank.

Story, Charles O. Three building models of fishing-vessels.

Tarr, Capt. Zebulon, and crew of schooner Mary Fernold. Mackerel-food (*Copepoda*) and small fish from mackerel stomachs; from Prince Edward's Island.

Thompson, Capt. Thomas, and crew of schooner Lizzie K. Clark. Crustaceans, mackerel-midges, and fishes; from off the coasts of Maine and Prince Edward's Island.

Wadsworth, Capt. James, and crew of schooner Conductor. Specimens of fishes (*Centroscyllium, Haloporphyrus, Synaphobranchus*), coral (*Alcyonium*), and sea feathers (*Pennatula* and *Balticina*); from George's Banks.

Wells, Captain, and crew of schooner H. A. Duncan. Specimens of fishes, star-fishes, crabs, sponges, &c.; from Brown's Bank and off Nova Scotia.

Wheeler, Captain, schooner Defiance. Sea-lamprey (*Petromyzon*) from off Thatcher's Island, and moon fish (*Parephippus*) from Ipswich Bay.

White, Capt. Thomas, and crew of schooner Martha and Susan. Specimens of fishes (*Chirostoma, Petromyzon*), crabs (*Hyas*), mussels (*Modiola*), sea-urchins, &c.; from Brown's and George's Banks.

Whitton, Capt. Owen A., and crew of schooner Wm. H. Oakes. Specimens of fishes (*Synaphobranchus, Myxine*), corals (*Keratoisis, Anthomastus, Para-*

Washington, D. C.—Continued.

United States Commission of Fish and Fisheries—Continued.

gorgia, Alcyonium), squid (*Architeuthis*), sponges (*Polymastia, Phakellia*), anemones, crinoids, &c.; from the Grand Banks.

Williams, Capt. B. A., and crew of schooner Centennial. Specimens of fishes (*Lycodes, Mallotus*), star-fishes (*Solaster, Asterias*) tunicates, sea-cucumbers, shells, &c.; from the Grand Bank.

Wilson, Mr. Specimens of fishes (*Solaster, Hippasteria*); from off Cape Breton Island.

Wonson, Everett. Laughing gull (*Larus atricilla*); from Brace's Cove, Gloucester.

Wonson, Fletcher. Calcareous rocks, &c.; from George's Bank.

Wonson, John F. Specimens American sole (*Achirus*) and calcareous rock, from the South Channel; and shells and barnacles from hull of bark *Santee* (Africa).

Wright, Capt. Frank, and crew of schooner Wachusett. Specimens of fishes (*Myxine*), scollops, whelks, sponges, corals (*Escharopsis, Primnoa*), sea-feathers, &c.; from the Grand Banks.

Navy Department:

Bureau of Steam Engineering. (See under name of *Passed Assistant Engineer H. C. Beckwith.*)

United States Navy. (See under names of *Commodore Earl English, Capt. R. Chandler, Commanders Lester A. Beardslee, R. D. Evans,* and *Ensign W. L. Wood.*)

Treasury Department:

United States Coast and Geodetic Survey, Capt. C. P. Patterson, Superintendent. (See under *W. H. Dall.*)

United States Revenue Marine. (See under *Dr. Robert White.*)

War Department:

Signal Service. (See under names of *Capt. H. W. Howgate* and *Private E. W. Nelson.*)

Surgeon-General's Office. (See under the names of *Drs. J. N. K. Corson, Elliott Coues, R. E. Lightburne, George H. Moran, C. A. Sewall,* and *H. W. Taylor.*)

Surveys west of the one hundredth meridian (*Capt. G. M. Wheeler in charge*). Ten boxes invertebrate fossils.

United States Army. (See under the names of *General M. C. Meigs, Lieut. Col. Richard J. Dodge, Captains Charles Bendire, E. Crawford, Levi Cromwell, James Gilliss, Lieuts. A. W. Greely, L. D. Green, H. Romeyn,* and *J. B. Sweitzer.*)

Wasson, John, United States Surveyor-General, Arizona. Specimens of minerals from various mining claims in Arizona.

Weeden, W. C. Three living blacksnakes (*Bascanion constrictor*), and skin of shrike; from Washington, D. C.

Weeks, Charles. Arrow-heads; from Maryland.

West, John. Specimens of stone implements; from Virginia.

West, William. Indian stone implements; from Virginia.

Westcott, O. S. Jaw of fresh-water drum (*Haploidonotus grunniens*); from Wisconsin.

Whittaker, E. W. Specimen of mineral.

White, Dr. C. A. A collection of fossils; from various localities.

White, H. G. Skin of titmouse (*Parus atricapillus*); from Taunton, Mass.

White, Dr. Robert, United States Revenue Marine. Six boxes of general natural history specimens; from Alaska.

White, Samuel (through Dr. A. P. L. Pease). Specimens of minerals; from Ohio.

White, Thomas J. Flint-lock pistol found at Harper's Ferry, W. Va.

Whitney, J. L. Copper ax and shell implement; from Ohio (purchased).

Wiggins, F. B. Three living possums; from Virginia.

Wiggins, John B. Three pieces of soapstone; from Virginia.

Wilcox, W. A. One hundred and thirty packages of fishing apparatus and samples of various preparations of fish.

Wilder, B. G. Living *Menobranchus;* from New York.

Wilkin, Dr. J. F. Tank of fishes; from Virginia.

Williams, Captain (through W. H. Dall). Specimen of seal (*Histriophoca equestris*); from Bering Sea.

Williams, Rev. G. F. Pottery figure (lent for casting).

Williams, J. G. Specimens of minerals; from Pennsylvania.

Wilmot, Samuel. Three specimens of salmon; from Canada.

Wilson, G. B. Box of birds' eggs; from Texas.

Wilson, Lewis (through Geo. A. Boardman). Specimen of bluefish; from Maine.

Winslow, Ensign Francis, Assistant United States Coast and Geodetic Survey. Bottle of alcoholic fishes; from the Chesapeake Bay.

Woltz, George. Living water-snake and five Indian arrow-heads; from Virginia.

Wood, J. W. Bottle of reptiles; from Wisconsin.

Woods, James. Indian drilled implement, with original drill; from New York (lent for casting).

Woods, M. L., Ensign U. S. N. Box of alcoholic specimens of reptiles; from Texas.

Woodman, Dr. H. T. Four boxes of Indian relics; from Iowa.

Wooster, A. F. Specimens of birds' eggs, minerals, and mosses.

Wooton, J. B. Specimens of insects.

Worth, S. G. Specimens of fish; from North Carolina.

Wright, Abel A. Water-beetle; from Georgia.

Wright, Isaac H. Box of fish-hatching apparatus.

Wyeth, John, & Brother, Philadelphia. Bottle of fluid extract of seawryack.

Zircle, Reuben. Specimens of stalagmitic formations; from New Market Cave, Va.

Zug, J. E. Specimen of granite.

A number of specimens of fishes, seeds, plants, minerals, Indian relics, birds, &c., have also been presented by unknown donors.

The following articles, which have been added to the collections of the National Museum, were presented to the United States Commission of Fish and Fisheries at the International Fisheries Exhibition, Berlin, 1880:

DENMARK:

Danish Commission. Two models of Danish fishing-vessels, a model of an eel-weir, and an eel-spear.

GERMANY:

Berlin Aquarium, Dr. Hermes. A number of fishes from the Berlin Aquarium.

Borne, Max von dem. Model of a fish-pond, a full size model of a sluice-way and gate for fish-pond; also, some fish-hatching apparatus.

Leipsic, Museum für Völkerkunde. A small collection of ethnological objects, principally African.

Oterendorp & Co., Nordernei. Model of a German fishing-vessel.

Peterson, Kuno; Flensburg. Model of a German trawling-vessel.

Schuster, Carl. Transportation can for fish.

HOLLAND:

Dutch Commission; A. E. Maas, commissioner. A model of a life-saving boat.

"*Neptunus*" *Company, Nieuwe Diep.* Model of a peculiar Dutch fishing-boat.

ITALY:

Italian Commission. A large series of canned fish.

Florence Natural History Museum, Prof. Enrico Giglioli. A small collection of Italian water-birds, and a series of Italian fishes in alcohol.

Genoa Natural History Museum, Dr. Decio Vinciguerra. A collection of Italian fishes in alcohol.

NORWAY:

Norwegian Commission. Models of five different Norwegian fishing vessels and boats. A model of a fisher-house at the Lofoten Islands. A collection of fishing gear, including lines, hooks, and trawl; besides a set of cooper's tools, used in making fish-barrels. Also a large series of samples of canned and dried fish.

Stavanger Preserving Company, Stavanger. A series of samples of canned fish.

RUSSIA:

Russian Commission. Specimen of fish isinglass, and a large and finely-illustrated work on the inland fisheries of Russia.

SWEDEN:

Swedish Commission. A series of samples of canned and dried fish.

REPORT OF EXPLORATIONS IN NEW MEXICO AND ARIZONA, BY JAMES STEVENSON.

Professor S. F. BAIRD:

DEAR SIR: I have the honor to present you herewith a brief statement of the explorations made by the party under my charge during last summer; giving, for the present, only an outline of the country traversed and the aggregate results accomplished.

The party arrived at Santa Fé, New Mexico, about the first of September last, where a few days were spent in arranging details for the prosecution of the field work.

From Santa Fé the party traveled direct to the pueblo of Taos, by way of the Rio Grande. At Taos about a week was spent in making collections; many sketches were made, representing picture-writing on the interior of the dwellings and estufas. Quite a number of photographic illustrations were made, showing the entire outlines of the village, including many details of its structure, sufficiently to construct a model. Portraits were also taken of the principal individuals of the pueblo.

From Taos the party proceeded southward to the pueblo of San Juan. From San Juan to Santa Clara, from Santa Clara to San Ildefonso, from there to Nambe, thence back to Santa Fé. A few days more were spent at the latter place in obtaining supplies for future work. We again proceeded southward to the pueblo of Cochiti, which is situated on the west bank of the Rio Grande, about 30 miles from Santa Fé. The party spent several days at this place making collections, photographic and other illustrations. From Cochiti we traveled westward about 30 miles to the pueblo of Jemez, situated near the sources of the Rio Jemez. At this village some days were spent in making collections, photographs, &c. From Jemez we followed up the Rio Jemez to the Hot Springs, near which we found several large ruins, both Indian and Spanish. Many views were made of the ruins, as well as a collection of pottery fragments, stone implements, &c. From Jemez our course was south, following the Jemez River. About ten miles below Jemez we found the pueblo of Silla, or Sia; here, too, a collection was made, and some photographs. Continuing down the river some miles, we reached the pueblo of Santa Ana. This pueblo we found to be much larger than any we had visited, except, perhaps, Taos. Our investigations at this pueblo were as full and complete as those made at the other pueblos. From Santa Ana we continued south, crossing the Rio Grande, to the pueblo of Sandia. At this village a full collection was made and an ample number of photographic illustrations to convey the fullest impression of the pueblo. From Sandia we moved on to Santo Domingo. This pueblo is located on the east bank of the Rio

Grande, and between that and the line of the Atchison, Topeka and Santa Fé Railroad. We also made a complete collection of pottery, &c., at this point. From here we continued our journey up the Rio Grande to the pueblo of San Félipé. Here we also spent several days making illustrations and collections. We then returned to Santa Fé, from where a special trip was made, via the railway, to the pueblo of Isleta. At each of the pueblos a sufficient time was taken to make investigations of all kinds in relation to the inhabitants, and to make a full typical collection of all their utensils, fabrics, &c., illustrating their industries, &c.

There are very many details and specimens of special interest which can only be presented after an examination of the sketches, photographs, and specimens.

The object of greatest interest to the party was the discovery of a class of ruins occupying a large area of country about 45 miles west of Santa Fé, and lying around the base of the Jemez Mountains, and between these mountains and the Rio Grande. These ruins extend in a semicircular manner from near Ildefonso around to the sources of the Rio Jemez, and are in depth from 3 to 15 miles. The houses are excavated in the faces of perpendicular bluffs composed of a soft volcanic tufa, very much resembling pumice stone; each bluff is shaped in its outlines somewhat like a horseshoe, the whole being situated in series, facing the river, and receding back from it, one above the other, toward the Jemez Mountains. The accompanying pencil sketches, by Mr. F. G. Galbraith, and one of the photographs will convey an impression of their appearance. From these ruins a large quantity of stone implements were collected.

One other locality which came within view of the party, but which was not examined for want of time, will prove of much interest. The locality referred to is on either side of the Upper Jemez River, which is bordered by numerous mesas from four to fifteen hundred feet in height, and much broken or cut up by cañons which have in many instances separated the mesas from each other. Located on the summits of these mesas we found twenty-seven villages in ruins, which we could only see with our glasses from the summit of a high mountain. The mesas on which these ruins are situated are so high and difficult of access that many days would be required to explore a single one of them.

In summing up the results of the work for the season, I can do no more than to give a list of the collections and illustrations made.

Photographs.—Twenty-two 11×14 views representing the pueblos of Taos, San Juan, Santa Clara, San Ildefonso, Pojanquiti, Tesuque, Nambe, Cochiti, Jemez, Jemez Ruins, Silla or Zia, Santa Ana, Sandia, Isleta, Santo Domingo, San Félipé, and Picoris. Twenty-one 8×10 portraits, embracing the governors and other principal persons of the Pueblo tribes visited.

Specimens.—Two thousand eight hundred specimens, embracing pottery, pestles, mortars, baking stones, grinders, polishing stones, drills, axes, spears, arrow-heads, scrapers, adzes, &c. Fabrics, such as blankets, waistlets, anklets, leggins, dresses, head-dresses, &c. Also, toys, bird-traps, spindle-whorls, gaming-stones, cart and plow, and many other objects too numerous to specify.

Hoping this brief statement may serve your purposes for the time being,

I am, very respectfully, your obedient servant,

JAMES STEVENSON.

RECEIPTS AND DISTRIBUTION OF SPECIMENS.

[These tables show only what has been recorded or entered in the detailed catalogues, constituting but a small proportion of the whole.]

Table showing the number of entries in the record-books of the United States National Museum at the close of the years 1879 *and* 1880, *respectively.*

Class.	1879.	1880.
Mammals	13,144	13,264
Birds	79,093	81,329
Reptiles and amphibians	10,407	10,517
Fishes	23,561	26,947
Skeletons and skulls	16,306	16,367
Eggs	18,049	18,189
Crustaceans	2,324	2,514
Annelids	100	100
Mollusks	33,169	33,169
Radiates	3,230	3,345
Invertebrate fossils	8,075	9,750
Minerals	20,450	20,450
Ethnological specimens	39,017	45,570
Total	266,925	281,511
Increase for 1880	....	14,586

Approximate table of the distribution of duplicate specimens to the end of 1880.

Class.	Total to end of 1879.		Distribution during 1880.		Total to end of 1880.	
	Species.	Specimens.	Species.	Specimens.	Species.	Specimens.
Skeletons and skulls	586	1,924	2	21	588	1,945
Mammals	2,167	4,822	2	3	2,169	4,825
Birds	27,940	42,318	185	199	28,125	42,517
Reptiles	2,566	4,158	24	33	2,590	4,191
Fishes	6,443	9,976	4,460	4,663	10,903	14,639
Nests and eggs of birds	8,234	20,511	162	403	8,396	20,914
Insects	4,538	10,091	151	240	4,689	10,331
Crustaceans	1,097	2,689	....	....	1,097	2,689
Shells	90,702	197,828	20	45	90,722	197,873
Radiates	593	793	....	....	593	793
Other marine invertebrates	1,907	5,240	7,351	8,194	9,258	13,434
Plants and packages of seeds	30,442	52,861	54	169	30,496	53,030
Fossils	4,391	10,518	26	26	4,417	10,544
Minerals and rocks	10,006	21,407	244	330	10,250	21,737
Ethnological specimens	6,849	5,494	35	289	3,884	5,783
Diatomaceous earths (packages)	1,174	1,928	2	82	1,176	2,010
Total	196,635	392,558	12,718	14,697	209,353	407,255

THE FIRST DECADE OF THE UNITED STATES FISH COMMISSION: ITS PLAN OF WORK AND ACCOMPLISHED RESULTS, SCIENTIFIC AND ECONOMICAL.

By G. Brown Goode.[*]

There are nine departments of the government devoted, in part or wholly, to researches in pure and applied science—the Geological Survey; the Coast and Geodetic Survey; the Naval Observatory; the National Museum; the Department of Agriculture; the Entomological Commission; the Tenth Census, with its special agencies for the study of the natural resources of the country; the Smithsonian Bureau of Ethnology, and the Commission of Fish and Fisheries. The Smithsonian Institution, established upon an independent foundation, should also be mentioned, as well as the Medical Museum of the Army, and the various laboratories under the control of the Army and Navy Departments.

The Geological Survey is not now carrying on any of the schemes of zoological and botanical investigation engaged in by its predecessors.

The work of the Entomological Commission and that of the census, though of extreme importance, are limited in scope and duration, while that of the Agricultural Department is necessarily, for the most part, economical.

The work of the National Museum is chiefly confined to the study of collections made by government surveys or individual collectors and sent in to be reported upon.

The work of the Fish Commission, in one of its aspects, may perhaps be regarded as the most prominent of the present efforts of the government in aid of aggressive biological research.

On the 9th of February, 1871, Congress passed a joint resolution which authorized the appointment of a Commissioner of Fish and Fisheries. The duties of the Commissioner were thus defined: "To prosecute investigations on the subject (of the diminution of valuable fishes) with the view of ascertaining whether any and what diminution in the number of the food-fishes of the coast and the lakes of the United States has taken place; and, if so, to what causes the same is due; and also whether any and what protective, prohibitory or precautionary measures should be adopted in the premises, and to report upon the same to Congress."

The resolution establishing the office of Commissioner of Fisheries required that the person to be appointed should be a civil officer of the government, of proved scientific and practical acquaintance with the fishes of the coast, to serve without additional salary. The choice was thus practically limited to a single man for whom, in fact, the office had been created. Professor Baird, at that time Assistant Secretary of the Smithsonian Institution, was appointed and entered at once upon his duties.

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[*] From the Proceedings of the American Association for the Advancement of Science, Vol. Boston Meeting, August, 1880.]

The summer of 1880 marks the tenth season of active work since its inception in 1871. The Fish Commission now fills a place ten-fold more extensive and useful than at first. The present essay aims to show, in a general way, what it has done, is doing, and expects to do—its purposes, its methods, its results.

The work is naturally divided into three sections:

1. The systematic investigation of the waters of the United States and the biological and physical problems which they present. The scientific studies of the Commission are based upon a liberal and philosophical interpretation of the law. In making his original plans the Commissioner insisted that to study only the food-fishes would be of little importance, and that useful conclusions must needs rest upon a broad foundation of investigations purely scientific in character. The life history of species of economic value should be understood from beginning to end, but no less requisite is it to know the histories of the animals and plants upon which they feed or upon which their food is nourished; the histories of their enemies and friends, and the friends and foes of their enemies and friends, as well as the currents, temperatures, and other physical phenomena of the waters in relation to migration, reproduction, and growth. A necessary accompaniment to this division is the amassing of material for research to be stored in the National and other museums for future use.

2. The investigation of the methods of fisheries, past and present, and the statistics of production and commerce of fishery products. Man being one of the chief destroyers of fish, his influence upon their abundance must be studied. Fishery methods and apparatus must be examined and compared with those of other lands, that the use of those which threaten the destruction of useful fishes may be discouraged, and that those which are inefficient may be replaced by others more serviceable. Statistics of industry and trade must be secured for the use of Congress in making treaties or imposing tariffs, to show to producers the best markets, and to consumers where and with what their needs may be supplied.

3. The introduction and multiplication of useful food-fishes throughout the country, especially in waters under the jurisdiction of the general government, or those common to several States, none of which might feel willing to make expenditures for the benefit of the others. This work, which was not contemplated when the Commission was established, was first undertaken at the instance of the American Fish Cultural Association, whose representatives induced Congress to make a special appropriation for the purpose. This appropriation has since

been renewed every year on a more bountiful scale, and the propagation of fish is at present by far the most extensive branch of the work of the Commission, both in respect to number of men employed and quantity of money expended.

Although activity in this direction may be regarded in the light of applied rather than pure scientific work, it is particularly important to the biologist, since it affords opportunities for investigating many new problems in physiology and embryology.

The origin of the Commission, its purposes, and methods of organization having been described, it now remains to review the accomplished results of its work. In many departments, especially that of direct research, most efficient services have been rendered by volunteers; in fact, a large share of what has been accomplished in biological and physical exploration is the result of unpaid labor on the part of some of the most skillful American specialists. Although it would be interesting to review the peculiar features of the work of each investigator, the limits of this paper will not allow even a mention of them all by name.

Since the important fisheries center in New England, the coast of this district has been the seat of the most active operations in marine research. For ten years the Commissioner, with a party of specialists, has devoted the summer season to work at the shore at various stations along the coast, from Connecticut to Nova Scotia.

A suitable place having been selected, a temporary laboratory is fitted up with the necessary appliances for collection and study. In this are placed from ten to twenty tables, each occupied by an investigator, either an officer of the Commission or a volunteer. From 1878 to 1879 important aid was rendered by the Secretary of the Navy, who detailed for this service a steamer to be used in dredging and trawling, and this year the steamer built expressly for the Commission is employed in the same manner.*

The regular routine of operations at a summer station includes all the various forms of activity known to naturalists—collecting along the shore, seining upon the beaches,† setting traps for animals not otherwise to be obtained, and scraping with dredge and trawl the bottom of the sea at depths as great as can be reached by a steamer in a trip of three

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* The number of dredging and trawling stations on record is as follows:

1871.	Wood's Holl	345
1872.	Eastport, 200 by hand, 35 by steamer	235
1873.	Portland	149
1874.	Noank	223
1875.	Wood's Holl	169
1877.	Salem	...
	Halifax	378
1878.	Gloucester	...
1879.	Provincetown	...
	Total	1,500

† The number of seine hauls is about 600.

days. In the laboratory are carried on the usual structural and systematic studies; the preparation of museum specimens and of reports. Since the organization of the Commission the deep-sea work and the investigation of invertebrate animals has been under the charge of Professor Verrill, who had for many years before the Commission was established been studying independently the invertebrate fauna of New England.

In addition to what has been done at the summer station, more or less exhaustive investigations have been carried on by smaller parties on many parts of the coast and interior waters. The fauna of the Grand Banks and other off-shore fishing grounds has been partly explored. In 1872, 1873, and 1874 dredging was carried on from the Coast Survey steamer *Bache* by Professor Packard and Mr. Cooke, Professor Smith, Mr. Harger, and Mr. Rathbun. In 1879 Mr. H. L. Osborne spent three months in a cod-schooner collecting material on the Grand Banks, and Mr. N. P. Scudder as long a time on the halibut grounds of Davis' Straits.

A most remarkable series of contributions has been received from the fishermen of Cape Ann. When the Fish Commission had its headquarters at Gloucester in 1878 a general interest in the zoological work sprang up among the crews of the fishing vessels, and since that time they have been vying with each other in efforts to find new animals. Their activity has been stimulated by the publication of lists of their donations in the local papers, and the number of separate lots of specimens received to the present time exceeds eight hundred. Many of these lots are large, consisting of collecting-tanks full of alcoholic specimens. At least thirty fishing vessels now carry collecting-tanks on every trip, and many of the fishermen, with characteristic superstition, have the idea that it insures good luck to have a tank on board, and will not go to sea without one. The number of specimens acquired in this manner is at least fifty or sixty thousand, most of them belonging to species unattainable. Each halibut vessel sets, twice daily, lines from ten to fourteen miles in length, with hooks upon them six feet apart, in water twelve hundred to eighteen hundred feet in depth; and the quantity of living forms brought up in this manner, and which had never hitherto been saved, is very astonishing. Over thirty species of fishes have thus been added to the fauna of North America, and Professor Verrill informs me that the number of new and extralimital forms thus placed upon the list of invertebrates cannot be less than fifty.

A permanent collector, Mr. Vinal N. Edwards, has been employed at Wood's Holl and vicinity since 1871, and many remarkable forms have also been discovered by him.

No dredging has yet been attempted by the Commission south of Long Island, though much has been done in shore work, especially among the fishes, by special agents and friends of the Commission, and by parties stationed here and there in the work of fish-culture. Mr. E. G. Blackford, of Fulton Market, New York, by carefully watching the market slabs, has added at least ten species of fishes to the fauna of the United States. Mr. F. Mather is studying the fish of Long Island and the sound. Dr. Yarrow, Mr. Earll, and others, have collected from Cape May to Key West. The Gulf States' coast was explored last winter by a party conducted by Mr. Silas Stearns, who spent nine months in studying the subject relative to food and the census. The entire Pacific coast has been scoured by Professor Jordan for the Commission and the census, and the ichthyology of that region has been enriched by the discovery of sixty species new to the fauna, forty of them being new to science. A similar investigation on the Great Lakes has been carried over a period of several years by Mr. Milner and Mr. Kumlien. The ichthyology of the rivers of the country has received much attention from the many experts employed by the Commission in fishcultural work.

In addition to these local studies may be mentioned the general explorations, such as are now being carried on for the oyster, by Mr. Ernest Ingersoll and Mr. John F. Ryder, for the shad by Colonel McDonald, for the smelt and the Atlantic salmon by Mr. C. G. Atkins, and the Quinnat salmon by Mr. Livingston Stone.

A partial indication of what has been accomplished may be found in the number of species added to the various faunal lists. Take, for instance, the cephalopod mollusks of New England. In Professor Verrill's recently published monographs, twenty species are mentioned, thirteen of which are new to science. Ten years ago only three were known.

I am indebted to Professor Verrill for the following estimate of the number of species added within the past ten years to the fauna of New England, mainly by the agency of the Commission:

	Formerly known.	Additions.	Now known.
Crustacea	105	193	298
Pycnogonida	5	10	15
Annelida	67	238	305
Vermes	39	100	139
Mollusca	317	109	426
Echinodermata	47	41	88
Anthozoa	20	35	55
Tunicata	26	25	51
Polyzoa	56	91	147
Brachiopoda	5	0	5
Sponges	10	80	90
Acalephæ	102	78	180
	800	1,000	1,800

It is but just to say that many of these species were obtained by Professor Verrill in the course of his independent explorations in Maine and Connecticut previous to 1871.*

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* A few days after the reading of this paper a new fauna was discovered about one hundred miles southeast of Newport, and several hundred numbers might now be added to this enumeration.

A similar estimate for the fishes indicates the discovery of at least one hundred species on the eastern Atlantic coast within ten years; half of these are new to science. Forty species have been added to the fauna north of Cape Cod; sixteen of these are new and have been found within three years; seventeen have been described as new from the Gulf of Mexico; sixty, and more, have been added upon the west coast. The results of the summers' campaigns are worked in winter by the specialists of the National Museum, and under the direction of Professor Verrill, in New Haven.

One of the important features of the work is the preparation of life histories of the useful marine animals of the country, and great quantities of material have been accumulated relating to almost every species. A portion of this has been published; more or less complete biographical monographs having been printed on the bluefish, the scup, the menhaden, the salmon, and the whitefish, and others are nearly ready.

Another monograph which may be referred to in this connection is that of Mr. Starbuck on the whale fishery, giving its history from the earliest settlement of North America.

The temperature of the water in its relation to the movements of fish has from the first received special attention. Observations are made regularly during the summer work, and at the various hatching stations. At the instance of the Commissioner, an extensive series of observations have for several years been made under the direction of the Chief Signal Officer of the Army, at light-houses, light-ships, life-saving and signal stations, carefully chosen, along the whole coast. This year thirty or more fishing schooners and steamers are carrying thermometers to record temperatures upon the fishing grounds, a journal of the movements of the fish being kept at the same time. One practical result of the study of these observations has been the demonstration of the cause of the failure of the menhaden fisheries on the coast of Maine in 1879—a failure on account of which nearly 2,000 persons were thrown out of employment.

Another important series of investigations carried on by Commander Beardslee, of the Navy, shows the error of the ordinary manner of using the Casella Miller deep-sea thermometer; still another series made by Dr. Kidder, of the Navy, and to be carried out in future, had for its object the determination of the temperature of the blood of marine animals.

Observations have also been made by Mr. Milner upon the influence of a change from sea water into fresh water, and from fresh water into sea water, upon the young of different fishes.

Mr. H. J. Rice carried on a series of studies upon the effect of cold in retarding the development of incubating fish eggs.

A series of analyses has been made by Professor Atwater to determine the chemical composition and nutritive value of fish as compared with other articles of food. This investigation is still in progress.

In connection with the work of fish culture, much attention has been paid to embryology. The breeding times and habits of nearly all of our fishes have been studied, and their relations to water temperatures. The embryological history of a number of species, such as the cod, shad, alewife, salmon, smelt, Spanish mackerel, striped bass, white perch, and the oyster, have been obtained, under the auspices of the Commission, by Messrs. Brooks, Ryder, Schæffer, Rice, and others.

The introduction of new species, in water in which they were previously unknown, is of special interest to the student of geographical distribution. Through the agency of the Commission the German carp has already been placed in nearly every State and Territory, although the work of distribution has only just begun, and the tench (*Tinca vulgaris*) and the golden orfe (*Idus melanotus*) have been acclimated; the shad has been successfully planted in the Mississippi Valley and on the coast of California, and the California salmon in the rivers of the Atlantic slope. The maræna, or lake whitefish, of Europe, has been introduced into a lake of Wisconsin. It is not my purpose to speak of the great success in restocking with shad and salmon several rivers in which the supply was almost exhausted, and in planting the Schoodic salmon in numerous lakes. By an act of international courtesy, California salmon have been successfully introduced into New Zealand and Germany. The propagation work has increased in importance from year to year, as may be seen by the constant increase in the amount of the annual appropriation. A review of the results of the labors of the Commission, in increasing the food supply of the country, may be found in the annual reports; the rude appliances of fish culture ten years ago have given way to scientifically devised apparatus, by which millions of eggs are hatched where thousands were, and the demonstration of the possibility of stocking rivers and lakes to any desired extent has been greatly strengthened. This work was for six years most efficiently directed by the late Mr. James W. Milner, and is now in charge of Maj. T. B. Ferguson, also commissioner for the State of Maryland, by whom has been devised the machinery for propagation on a gigantic scale, by the aid of steam, which is now so successfully in use, revolutionizing the art of fish culture.

The investigation of the statistics and history of the fisheries has perhaps assumed greater proportions than was at first contemplated. One of the immediate causes of the establishment of the Commission was the dissension between the line and net fishermen of Southern New England with reference to laws for the protection of the deteriorating fisheries of that region. The first work of Professor Baird, as Commissioner, was to investigate the causes of this deterioration, and the report of that year's work includes much statistical material. In the same year a zoological and statistical survey of the Great Lakes was accomplished, and various circulars were sent out in contemplation of the preparation of monographic reports upon the special branches of the fisheries, some of which have already been published.

In 1877, the Commissioner and his staff were summoned to Halifax to serve as witnesses and experts before the Halifax Fishery Commission, then charged with the settlement of the amount of compensation to be paid by the United States for the privilege of participating in the fisheries of the Provinces. The information at that time available concerning the fisheries was found to be so slight and imperfect that a plan for systematic investigation of the subject was arranged and partially undertaken. The work was carried on for two seasons with some financial aid from the Department of State. In 1879 an arrangement was made with the Superintendent of the Tenth Census, who agreed to bear a part of the expense of carrying out the scheme in full. Some thirty trained experts are now engaged in the preparation of a statistical report on the present state and the past history of the fisheries of the United States. This will be finished next year, but the subject will hereafter be continued in monographs upon separate branches of the fisheries, such as the halibut fishery, the mackerel fishery, the shad fishery, the cod fishery, the herring fishery, the smelt fishery, and various others of less importance.

Hundreds, and even thousands, of specimens of a single species are often obtained. After those for the National Museum have been selected, a great number of duplicates remain. These are identified, labeled, and made into sets for exchange with other museums for distribution to schools and small museums. This is in accordance with the time-honored usage of the Smithsonian Institution, and is regarded as an important branch of the work. Several specialists are employed solely in making up these sets and in gathering material required for their completion. Within three years fifty sets of fishes in alcohol, including at least ten thousand specimens, have been sent out, and fifty sets of invertebrates, embracing one hundred and seventy-five species and two hundred and fifty thousand specimens. One hundred smaller sets of representative forms intended for educational purposes, to be given to schools and academies, are now being prepared.

The arrangement of the invertebrate duplicates is in the charge of Mr. Richard Rathbun; of the fishes, in that of Dr. T. H. Bean.

Facilities have also been given to many institutions for making collections on their own behalf.

Six annual reports have been published, with an aggregate of 5,650 pages. These cover the period from 1871 to 1878. Many papers relating to the work have been published elsewhere—particularly descriptions of new species and results of special faunal exploration.

AN EPITOME OF THE HISTORY OF THE COMMISSION.

1871.—The Commissioner, with a party of zoologists, established the first summer station at Wood's Holl, Mass., other assistants being engaged in a similar work at Cape Hatteras and the Great Lakes. He also personally investigated the alleged decrease of the fisheries in southern New England, taking the testimony of numerous witnesses.

1872.—This year the summer station was at Eastport, Me., particular attention being paid to the herring fisheries. The survey of the Great Lakes was continued. Dredging, under the direction of Professor Packard, was begun on the off-shore banks. At the instance of the American Fish Cultural Association, Congress requested the Commissioner to take charge of the work of multiplying valuable food fishes throughout the country. Work was begun on the shad, salmon, and whitefish, and the eggs of the European salmon were imported.

1873.—The summer headquarters were fixed at Portland, Me. The opportunities for research were greatly increased by the aid of the Secretary of the Navy, who granted the use of an eighty-ton steamer. Explorations in the outer waters between Mount Desert and Cape Cod were carried on in the United States Coast Survey steamer *Bache*. Operations in fish culture were carried on upon an extensive scale.

1874–1875.—In 1874 the zoological work centered at Noank, Conn. The attempt was made to introduce shad into Europe. In 1875 the station was for a second time at Wood's Holl, where a permanent seaside laboratory, with aquaria, was now established. The number of investigations this year was about twenty. The increase in the propagation work was proportionately much larger.

1876.—This year the Commissioner was unable to take the field for fishery investigations, having been instructed to exhibit, in connection with the Philadelphia International Exhibition, the methods of fish culture and the American fisheries. Much, however, was accomplished by single investigators in various localities. The propagation work continued. This year the first carp were introduced from Germany.

1877.—The field of investigation was resumed at Salem, Mass., and later at Halifax, Nova Scotia. A large steamer of 300 tons made deep-sea research possible. The Commissioner and his staff served as experts before the Halifax Fishery Commission. The propagating work was on the increase, and the government carp ponds were established in Washington.

1878–1879.—In 1878 the summer station was at Gloucester, Mass.; in 1879 at Provincetown. These centers of the fishing interests were selected that more attention might be devoted to studying the history, statistics and methods of the sea fisheries; a plan for the systematic investigation which seems yearly more necessary in view of the dissensions between the governments of the United States and Great Britain. In 1879 a combination was formed with the Superintendent of the Tenth Census, by which the Commissioner was enabled to carry more rapidly forward this branch of the work. Specialists were dispatched to all parts of the country to study the biological, statistical, and practical aspects of the fisheries. In 1878 the breeding of cod and haddock was accomplished at Gloucester. In 1879 the propagation of the oyster was accomplished, by co-operation with the Maryland Commission under the direction of Major Ferguson, and the distribution of the carp throughout the country was begun.

1880.—The summer station is at Newport, R. I. The *Fish Hawk*, a steamer of 484 tons, constructed expressly for the work of the Commission, lies at the wharf, now equipped for scientific research, later to be employed in the propagation of sea fish, such as the cod and the mackerel. Over fifty investigators are in the field in the service of the Commission. The season was opened by the participation of the Commission in the International Exhibition at Berlin. The first honor prize, the gift of the Emperor of Germany, was awarded to Professor Baird, not alone as an acknowledgment that the display of the United States was the most perfect and most imposing, but as a personal tribute to one who, in the words of the President of the Deutscher Fischerei Verein, is regarded in Europe as "the first fishculturist in the world."

SPECIAL REPORT OF THE EXECUTIVE COMMITTEE.

PRESENTED TO THE BOARD OF REGENTS DECEMBER 8, 1880.

To the Board of Regents of the Smithsonian Institution:

GENTLEMEN: The Board of Regents has been called to this special meeting at the request of the Executive Committee to consider two subjects of importance, requiring action before its regular annual session.

At the last session of Congress the following act was passed:

AN ACT for the erection of a bronze statue of Joseph Henry, late Secretary of the Smithsonian Institution.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Regents of the Smithsonian Institution be, and are hereby, authorized to contract with W. W. Story, sculptor, for a statue in bronze of Joseph Henry, late Secretary of the Smithsonian Institution, to be erected upon the grounds of said Institution, and for this purpose, and for the entire expense of the foundation and pedestal of the monument, the sum of fifteen thousand dollars is hereby appropriated out of any moneys in the Treasury not otherwise appropriated.

Approved June 6, 1880.

(Forty-sixth Congress, second session, chapter 116.)

The Secretary of the Institution immediately informed Mr. Story of this action of Congress, and requested his views on the subject and information as to his acceptance of the commission.

This correspondence is as follows:

"SMITHSONIAN INSTITUTION,
"*Washington, D. C., June* 10, 1880.

"SIR: A bill providing for the erection of a statue of Prof. Joseph Henry, late Secretary of the Smithsonian Institution, introduced by Senator Morrill, has become a law. A copy of this is herewith inclosed.

"As you will see, its essential points are the provision for a bronze statue of Professor Henry, to be placed in the Smithsonian grounds, and that the total cost, including expenses for the pedestal, &c., shall not exceed $15,000.

"I beg to inquire whether you will accept the commission under these conditions; and presuming that you will, I forward herewith as full a series of photographs of the illustrious deceased as can be supplied by the Institution. This series includes those which in the opinion of Professor Henry's family are most characteristic likenesses.

"I shall be pleased to have from you any communication on this subject, and, if possible, designs for the proposed statue and pedestal, for communication to the Board of Regents at their next annual meeting in January, 1881.

"As this Board is to decide upon the construction of the statue, it will not be possible to give you final authority in the matter until the Board shall have taken action thereon.

"I am, meanwhile, very truly yours,

"SPENCER F. BAIRD,
"*Secretary.*

"W. W. STORY, Esq.,
"*American Sculptor, Rome, Italy.*

Letter of Mr. Story to Professor Baird.

"VENICE, *July* 15, 1880.

"SIR: I have just received your letter of June 10, informing me of the bill lately passed by Congress, by which the Regents of the Smithsonian Institution are authorized to contract with me for a statue in bronze of the late Professor Henry, for the sum of $15,000, including the foundation and pedestal of the monument, and asking me whether I will accept this commission.

"Mr. Senator Morrill had already communicated to me this entirely unexpected and agreeable news. Until his communication was made, I had no notion that it was intended to erect such a statue, but I most willingly accept the commission, with hearty thanks to those friends who, without any knowledge on my part, put forward my name as the sculptor.

"My recollections of Professor Henry are in every way most pleasant. He was very kind to me when I was last in Washington, and it will give me pleasure to do all in my power to make a statue of him worthy of his high distinction and his amiable character.

The photographs which you have had the kindness to send have not yet arrived, but I have little doubt that they will supply me with the necessary material. As you say nothing of a mask in plaster from the face, I suppose none was taken. This I greatly regret, as it would furnish me, in connection with the photographs, the absolute facts of the face, as well as the character and expression. If such a mask was taken, or anything was ever made of him containing the exact measures of his face and features, I should be most glad to have them. If any bust was ever made, however bad, it would be of use to me in determining points of size and measurement. I hope, too, there may be among the photographs some one or more in *profile*, or at least *three-quarters* face. Do not in such case be prevented from sending them merely because they are bad in expression or otherwise. What I want is facts, and the more I can have of these the better. They will not lead me astray as to expression. Small facts and details may be explained in one which are not clearly determined in another, and enable me to make the head more living and true.

"I regret to hear that no absolute action can be taken by the Board before January 1, 1881. This will greatly delay the execution of the statue, to which I was intending to devote myself immediately on my return to Rome in October or November, so as to be able to finish the model this winter. But if all final arrangement is postponed until January before the absolute commission can be given and the contract made, the winter will have passed, and the execution of the statue will, I fear, be necessarily postponed for a year, as it is impossible for me to remain in Rome and execute the model during the summer without very great inconvenience and difficulty.

"You wish me to send you, if possible, designs for the proposed statue and pedestal, for communication to the Board of Regents at their annual meeting in January, 1881. Of course I can do this, if they think it advisable or necessary; but I must frankly say—I hope they will excuse me in so saying, as no kind of disrespect is intended, or want of confidence in their taste and judgment—that I think, if they have any faith in my ability, it would be better for them to leave the conception and execution of the statue entirely to me. There is nothing so dangerous as to interfere with an artist in his design, or to judge of it and criticise it from a small model. The freer he is, the more responsible he feels, and, if he has real ability, the less he is tampered with and directed, the better his work will be. If he has not the requisite ability to do it by himself, he should better not do it at all. No suggestions by any committee and no directions and alterations will ever make his work good. My own experience has been that this divided responsibility and designing has almost invariably resulted in dissatisfaction on both sides. The artist can only do well with what is in his own mind, and not what is in the mind of others, and my own judgment is that he does far better when left to himself, always provided he has real capacity for his work. If I may be allowed to allude to my own personal experience, I may add that in the case of almost the only public portrait statue of mine in America, the committee, composed of gentlemen of high taste and pretension to artistic culture, after rejecting my own first sketch, and insisting on my altering the attitude and arrangement to meet their views, contrary to my notions, were finally persuaded, when the work was completed and it was too late, that they had been entirely wrong in dictating these changes, and regretted that they had interfered. Nevertheless they threw upon me the responsibility which belonged solely to them. I made *their* statue and not *mine*, and they were disappointed, as I foretold that they would be. But I do not need to speak of my own personal experience; the experience of all artists is the same on this point.

"However, if despite this, the Board desires me to send them a sketch I can do so; but of course, as I have stated, this will delay the statue for a year, and I cannot see the advantage.

"In fact, I have already made a sketch of the statue since I received Mr. Morrill's communication. But I doubt whether it would mean as much to you and to the Board of Regents as it does to me; whether you would rightly understand it in its roughness, and whether you would not look for that finish which no free sketch ought to have, and rather look to details than to matters and balance of composition, which are the all in all of a sketch. I say this because I know one case where a sketch was rejected because the likeness in the face was not striking, as if any true artist would, in a mere sketch, attempt exact portraiture of the face. It would be equally good as to composition and design with no face at all, if it had the just movement.

"You say nothing as to details of the commission, or the size of the statue, or the place where it is to be erected, or its surroundings. Is it to be in the open air, or under cover in the buildings? Is its background trees, sky, or building? All these are very important considerations in view of its effect and of its size.

"I take it for granted that the pedestal is to be a simple one, and not to have illustrative bas-reliefs or figures, inasmuch as the sum appropriated for the whole thing is less, or certainly not more, than what is ordinarily paid for a statue alone without pedestal or foundation. I also suppose by the reading of the act of Congress that this sum is to cover the cost of the statue and "the entire expense of the foundation and pedestal," and this is all. It does not, as I understand it, include boxing, transportation, insurance, and placing, as they are distinctly not mentioned.

"Can you give me an estimate of the cost of making the foundation, and approximate price of a simple pedestal executed in Washington, in marble or red granite, or stone of any appropriate kind? This would guide me in determining where I should make the pedestal, whether here or in Washington, and of what material.

"As to the sum of $15,000 appropriated by Congress, does interest run upon it from the date of the enactment? In regard to payment I suppose you are aware that the ordinary rule is to advance to the artist one-half the sum when the commission is given, or the work commenced, to enable him to meet the necessary outlay and expenses, without recourse to his own pocket.

"I mention all these particulars in order to avoid all misunderstanding.

"I again recur to the question of time, and I earnestly hope that it will be possible for the Board of Regents to arrange definitely this whole matter at a much earlier period than that mentioned in your letter, viz: January 1, 1881, as it will involve the loss of a year. If I could have the commission and authorization to commence the work by the 1st of October or November, I could finish the model by the spring and immediately arrange for its casting in bronze during the summer so as to have it ready to send to Washington by the 1st of October following (1881).

"I suppose that the Board of Regents is equally interested with myself in desiring the statue to be finished as soon as possible, and if they will definitely authorize me to begin the model by the 1st of November, I can promise, unless some unforseen accident occurs, to finish it in bronze by the 1st of January, 1882; otherwise I fear we shall have to put it forward to January, 1883.

"If the Board of Regents have faith in my ability and will trust me to follow out my own ideas in this statue, I will pledge myself to do my best to satisfy myself and them, and to spare no pains to give them a statue worthy of the subject, worthy of the place, and satisfactory to the family, friends, and admirers of Professor Henry.

"You must not expect too much. The male costume of the present day is crude, graceless, and thoroughly unsculptural. But I will do what I can to hide its awkwardness and ugliness without falsifying truth and fact, and endeavor to render the statue serious and dignified and natural. I suppose that Professor Henry had no academic costume, and that there is no peculiar professional dress in which he could be represented. If there be, and the Board of Regents is willing that I should clothe the statue in such a dress, I should most gladly do it. Then I should be able to drape him in some way at once dignified and true to fact. The academic costume could be treated so as to make an imposing statue. In such case, would you have the kindness to forward to me the dress, that I may use it to model from? The silk academic robes would be admirable and advisable, but I scarcely dare to hope that he wore one, or that I may use it. What did he wear? If this academic dress is out of the question, what may I represent him in? Did he wear a cloak?

"The sketch I have made represents him as in a buttoned frock-coat, over which is a loose open sack; it is in the attitude of meditation; his head bent slightly forwards, looking down, one hand resting on a desk or stand at his side, by which to break the horrible uniformity of the two legs of pantaloons, and give breadth and dignity to the base, and one hand across the breast midway, at the place of the upper button of the buttoned coat; on the stand are books on which his left hand is placed. On the whole, those who have seen it, think it simple, dignified, and thoughtful. If it is to be made in coat and trousers, I doubt if I could do better, but I shall think it over and make other sketches.

"Will you be kind enough to send me any memoir that may exist of Professor Henry, so that I may have a more thorough knowledge of his character and services and labors than I now have. I beg you not to forget this, as it will greatly assist me in determining the exact character to be given to the statue.

"I have written you a very long letter in the hope of clearing the way of all obstacles, and of letting you understand exactly what my views and wishes are.

"Yours, faithfully,

"W. W. STORY."

During the recess of Congress it was found impracticable to call a meeting of the Regents, but their views were asked individually by the Secretary as to the power of the Executive Committee to make a formal contract with the artist and enable him to go on with the work.

The opinion of the majority was that this power could be exercised by the Executive Committee. A meeting was therefore called of this Committee on the 13th of November, 1880, when the subject was fully considered and the following action taken:

"*Resolved*, That the Secretary of the Smithsonian Institution inform Mr. Story that the Executive Committee authorize him to proceed in the execution of the bronze statue ordered by Congress June 1, 1880, according to his own plan and designs, but that this Committee is not empowered to make a formal contract for this purpose, although warranted in such action by the individual expressions of Regents as contained in letters received by the Secretary.

"*Resolved*, That a special meeting of the Regents be called on the 8th of December, 1880, to consider the subject, and if the action of the Executive Committee is not confirmed, a cable message be immediately sent to Mr. Story, and, if approved, a contract in due form be made out and transmitted to him."

This action of the Committee was communicated to Mr. Story by the Secretary on the 13th of November.

Another subject demanding the consideration of the Board has been presented to the Executive Committee.

A committee of citizens of Washington having presented a request for the use of the new National Museum building for a reception to the President of the United States elect, on the 4th of March next, after a full consideration of the subject, in view of the fact that the building is unfinished and not yet occupied as a Museum, and that such a contingency would not again occur and would not therefore furnish a precedent; in view also of the fact that the expense of erecting a suitable building would be very great and unnecessary, and, moreover, that the President elect is and has been for many years a member of the Board of Regents, whose aid and influence contributed materially to the erection of the new Museum, the Committee adopted the following:

"Whereas an application has been received from a committee of citizens for the use of the unfinished building of the National Museum, for the purpose of a public reception to the President elect, Hon. James A. Garfield, on the evening of the 4th of March next; therefore,

"*Resolved*, That the Executive Committee submit this application to the Board of Regents at its next meeting, with its approval and with the recommendation that the request be granted."

The Committee furthermore make the following statement:

The new National Museum building has been substantially completed and made ready for occupancy within the appropriations by Congress. A detailed account of the history of operations of its construction will be presented at the annual meeting of the Board in January next.

The Building Commission has refrained from completing the floors of the rotunda and large halls or naves according to the original plans, which provided only for concrete and cement, on account of the remonstrances of prominent members of Congress, who urged that such floors were unsuitable to, and unworthy of, so fine a building, and their assurances that appropriations would doubtless be made at the approaching session of Congress for marble or tile floors for these halls.

The Committee report that provision has been made so that the floors of the rotunda and four naves leading to the main entrance of the building may be laid in marble or tile instead of cement, and that if an appropriation of $25,000 be made immediately, the building will be ready for the reception of the President on the 4th of March next, fully adapted and provided with heat, light, and all the facilities required for the occasion.

In conclusion, the Committee respectfully submit the following resolutions to the Board for adoption:

"*Resolved*, That the Chancellor and Secretary of the Smithsonian Institute execute a contract with Mr. W. W. Story, of Rome, for the statue in bronze of the late Prof. Joseph Henry, authorized by the act of Congress of June 1, 1880, with the provision for payment of the sum of $3,750 to Mr. Story on completion of his design for the statue; the sum of $3,750 on completion of the model in clay; the sum of $3,750 on completion of the statue in bronze; and the sum of $3,750 on delivery and erection of the statue with its pedestal in the city of Washington, on the grounds of the Smithsonian Institution, and furthermore that Mr. Story shall cause the said statue to be insured for the amount of the advance payments to him, against perils by land or by sea, which insurance shall, in case of loss, be paid to the Smithsonian Institution for the benefit of the United States.

"*Resolved*, That for the purpose of substituting a marble or tile flooring, instead of concrete, as originally designed, for the large halls in the National Museum, an appropriation of twenty-five thousand dollars be requested of Congress, to be expended according to the plans and under the direction of the building commission of the Board of Regents of the

Smithsonian Institution, under whose supervision the Museum has been erected.

"*Resolved*, That the use of the new National Museum building be granted for the inaugural reception of the President of the United States on the 4th of March, 1881, and that the Secretary be authorized to make all necessary arrangements for this purpose."

Respectfully submitted.

PETER PARKER,
W. T. SHERMAN,
Executive Committee.

WASHINGTON, 8th *December*, 1880.

REPORT OF THE EXECUTIVE COMMITTEE OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION FOR THE YEAR 1880.

The Executive Committee of the Board of Regents of the Smithsonian Institution respectfully submit the following report in relation to the funds of the Institution, the appropriations by Congress for the National Museum and other purposes, the receipts and expenditures for both the Institution and the Museum for 1880, and the estimates for the year 1881.

Condition of the funds January 1, 1881.

The amount originally received as the bequest of James Smithson, of England, deposited in the Treasury of the United States, in accordance with the act of Congress of August 10, 1846	$515,169 00	
The residuary legacy of Smithson, received in 1865, added to the fund, by authority of Congress, February 8, 1867	26,210 63	
Amount added to the fund, derived from savings, &c., by authority of Congress, February 8, 1867	108,620 37	
		$650,000 00
Amount added to the fund from the bequest of James Hamilton, of Pennsylvania, 1874	1,000 00	
Amount added to the fund from the bequest of Dr. Simeon Habel, 1880	500 00	
		1,500 00
Total permanent Smithson fund in the Treasury of the United States bearing interest at 6 per cent., payable semi-annually		651,500 00
In addition to the above the Institution has invested in Virginia bonds and certificates $88,125.20, valued January 1, 1881, at		47,000 00
Also the cash balance in the United States Treasurer's hands January 1, 1881		20,934 52
Total Smithson funds January 1, 1881		$719,434 52

The following is a statement of the receipts and expenditures for the year 1880:

RECEIPTS.

Interest on $650,000 for the year 1880, at 6 per cent		$39,000 00
Interest on Virginia bonds, sale of coupons by Riggs & Co. for January 1 and July 1, 1880, for $3,522 (November, 27, 1880), less commission		3,239 76
Interest on Hamilton fund of $1,000 for the year 1880		60 00
Interest on the Habel fund of $500 from March 15, 1880, to December 31, 1880		23 88
		42,323 64
Balance on hand at the beginning of 1880		20,894 06
Total for 1880		63,217 70

EXPENDITURES.

Buildings:		
Repairs and improvements	$1,722 71	
Furniture and fixtures	369 15	
		$2,091 86
General expenses:		
Meetings of the Board	327 25	
Lighting the building	29 15	
Heating the building	572 11	
Postage and telegraphing	324 74	
Stationery	888 07	
Incidentals, blanks, hauling, &c	853 76	
Salaries	12,700 00	
Extra clerk hire and labor	295 00	
Books and periodicals	889 71	
		16,879 79
Publications and researches:		
Smithsonian Contributions	5,358 95	
Smithsonian Miscellaneous Collections	4,844 66	
Smithsonian annual reports	731 66	
Researches	400 44	
Explorations	1,191 59	
Laboratory	194 68	
		12,721 98
Exchanges:		
Literary and scientific		9,996 05
Gallery of art:		
Purchase of articles		93 50
Increase of the permanent fund:		
Deposited in United States Treasury as Habel bequest		500 00
Total expenditures		42,283 18
Balance on hand in Treasury of the United States January 1, 1881		20,934 52

VIRGINIA STOCK.

The Institution owns the following bonds and certificates:

Consolidated bonds:		
58 bonds, Nos. 11521 to 11578 inclusive, for $1,000 each	$58,000 00	
1 bond, No. 1380, for	500 00	
2 bonds, Nos. 4191 and 4192, for $100 each	200 00	
		$58,700 00

These are deposited with the Treasurer of the United States.

Deferred certificates:		
1 certificate, No. 4543	29,375 07	
1 certificate, No. 2969	50 13	
		29,425 20

These are deposited with Riggs & Co.

Total par value of Virginia securities	88,125 20
The estimated value of which by Riggs & Co. January 1, 1881, is	47,000 00

The coupons on the consolidated bonds are receivable for taxes in Virginia, and were sold for the Institution by Riggs & Co. November 27, 1880, viz, $3,522 at an average of 92, yielding $3,239.76. (See Receipts.)

It is gratifying to notice the improvement of the Virginia securities, the increased value of those held by the Institution being $15,910 since the report of the committee last year.

HAMILTON BEQUEST.

The Institution derived from the bequest of James Hamilton, of Carlisle, Pa., February 24, 1874, one thousand dollars, the interest on which is to be appropriated biennially for the promotion of science. The principal is deposited in the Treasury of the United States as an addition to the permanent Smithson fund. The interest received on this fund during 1880, was $60.

HABEL BEQUEST.

Among the receipts for the year 1879 was a bequest of $402.59, by Dr. Simeon Habel, of New York. With the sanction of the Executive Committee, the Secretary added to this sum $97.41 from the annual income of the Institution to increase it to $500, and this was deposited in the United States Treasury as a part of the Smithson fund, to be known as the Habel bequest. This deposit was made on the 15th of March, 1880, the interest on which to the end of the year was $23.88, as specified in the receipts.

ESTIMATES FOR 1881.

The following are the estimates of receipts by the Institution for the year 1881, and of the expenditures required for carrying on its operations during the same period;

RECEIPTS.

Interest on the permanent Smithson fund receivable July 1, 1881, and January 1, 1882	$39,000 00	
Interest on the Hamilton fund	60 00	
Interest on the Habel fund	30 00	
Sale of Virginia coupons, due January 1 and July 1, 1881	3,000 00	
		$42,090 00

EXPENDITURES.

For building	$2,000 00	
For salaries	12,700 00	
For general expenses other than salaries	1,300 00	
For publications and researches	14,000 00	
For exchanges	10,000 00	
For books and apparatus	1,000 00	
For contingencies	1,090 00	
		$42,090 00

NATIONAL MUSEUM AND OBJECTS COMMITTED BY CONGRESS TO THE SMITHSONIAN.

The following appropriations were made by Congress in 1880, for disbursal under the direction of the Smithsonian Institution:

Preservation of collections, Smithsonian Institution: "For preservation and care of the collections of the surveying and exploring expeditions of the government and the objects presented to the United States at the International Exposition of 1876." (Forty-sixth Congress, second session, chapter 235; 1880) Balance available January 1, 1881, $23,273.17.	$45,000 00
Preservation of collections, Smithsonian Institution—Armory Building: "For expense of watching, care, and storage of articles belonging to the United States, including those transferred from the International Exhibition of 1876, and for transfer to the new National Museum." (Forty-sixth Congress, second session, chapter 235; 1880) Balance available, $1,366.05.	2,500 00

For furniture and fixtures, National Museum: “For cases, furniture, and fixtures for the reception, care, and exhibition of the collections of geology, mineralogy, ethnology, technology, and natural history, presented to the government by foreign nations.” (Forty-sixth Congress, second session, chapter 235; 1880)………	$50,000 00
Balance available, $44,251.07.	
“For a steam-heating apparatus and for fuel: to be immediately available.” (Forty-sixth Congress, second session, chapter 235; 1880)………	25,000 00
“For water, gas fixtures, and electrical apparatus, to be immediately available.” (Forty-sixth Congress, second session, chapter 235; 1880)………	12,500 00
Balance available, $5,050.33.	
“For construction of relieving sewer, with the necessary manholes and traps from the new National Museum building to the Seventh street sewer.” (Forty-sixth Congress, second session, chapter 235; 1880)………	1,000 00
No portion expended.	
“For the purpose of continuing ethnologic researches among the North American Indians under the direction of the Secretary of the Smithsonian Institution.” (Forty-sixth Congress, second session, chapter 235; 1880)………	20,000 00
Balance available, $7,308.32.	
“For completing the preparation, with the necessary illustrations, of the report of Dr. Emil Bessels, of the scientific results of the Arctic expedition under the late Capt. C. F. Hall, to be expended under the control of the Smithsonian Institution.” (Forty-sixth Congress, second session, chapter 234; 1880)………	8,000 00
Balance available, $6,183.66.	

CONCLUSION.

The Executive Committee has examined 682 vouchers for payments made from the Smithson income during the year 1880, and 791 vouchers for payments made from appropriations by Congress for the National Museum, making a total of 1,473 vouchers. All these bear the approval of the Secretary of the Institution and a certificate that the materials and services charged were applied to the purposes of the Institution or the Museum.

The Committee has examined the account-books of the National Museum, and find the balances remaining on hand as before stated, viz: “Preservation of collections,” $23,273.17; “Armory building,” $1,366.59; “Furniture and fixtures,” $44,251.07, to correspond with the certificate of the disbursing clerk of the Department of the Interior, and the balance for “fire-proof building for National Museum,” $5,050.33, “Po

66, to correspond with the certificates of the disbursing easury Department.

accounts-current, bank-book, check-book, and journals en examined and found to be correct.

the credit of the Institution proper, on the 1st of Jan- hands of the Treasurer of the United States, available erations of the Institution, is $20,934.52.

bmitted.

PETER PARKER,
W. T. SHERMAN,
JOHN MACLEAN,
Executive Committee, Smithsonian Institution.

nuary 18, 1881.

JOURNAL OF PROCEEDINGS OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION.

WASHINGTON, *December* 8, 1880.

A meeting of the Board of Regents of the Smithsonian Institution was held this day at 10.30 o'clock in the Regents' room of the Institution.

Present: The Chancellor, Chief Justice Waite; Hon. W. A. Wheeler, Vice-President of the United States; Hon. H. Hamlin, Hon. R. E. Withers, Hon. N. Booth, Hon. H. Clymer, Hon. Joseph E. Johnston, Hon. Peter Parker, General William T. Sherman, Prof. H. Coppée, and Professor Baird, Secretary.

The Chancellor stated that this was a special meeting of the Board called at the request of the Executive Committee. A report of this committee was presented by the chairman, Dr. Parker.

After a full discussion of the subjects presented in the report, the following resolutions were unanimously adopted.

(In reference to the statue of Professor Henry.)

Resolved, That the Chancellor and Secretary of the Smithsonian Institution execute a contract with Mr. W. W. Story, of Rome, for the statue in bronze of the late Prof. Joseph Henry, authorized by the act of Congress of June, 1, 1880, with the provisions for payment of the sum of $3,750 to Mr. Story on completion of his design for the statue; the sum of $3,750 on completion of the model in clay; the sum of $3,750 on completion of the statue in bronze; and the sum of $3,750 on delivery and erection of the statue with its pedestal in the city of Washington, on the site to be selected by the Executive Committee; and furthermore that Mr. Story shall cause the said statue to be insured for the amount of the advance payments to him against perils by land or by sea, which insurance shall, in case of loss, be paid to the Smithsonian Institution, for the benefit of the United States.

(In reference to the new Museum building.)

Resolved, That for the purpose of substituting a marble or tile flooring instead of concrete as originally designed for the large halls in the National Museum, an appropriation of $25,000 be requested of Congress, to be expended according to the plans and under the direction of the Building Commission of the Board of Regents of the Smithsonian Institution, under whose supervision the Museum has been constructed.

(In reference to the use of the new Museum for the inaugural reception.)

Whereas the new Museum building is unfinished and not ready for occupancy for the government collections, and such a contingency will not again occur, and that no precedent is to be given for the use of the building for other purposes:

Resolved, That the use of the new National Museum building be granted for the inaugural reception of the President of the United States, on the 4th of March, 1881, and that the Secretary of the Smithsonian Institution be authorized to make all necessary arrangements for this purpose.

The Board then adjourned, at 12:30 P. M.

WASHINGTON, *January* 19, 1881.

In accordance with a resolution of the Board of Regents of the Smithsonian Institution fixing the time of the beginning of the annual session on the third Wednesday in January of each year, the Board met to-day at 10:30 o'clock, A. M.

Present: The Chancellor, Chief Justice M. R. Waite; the Vice-President of the United States, Hon. W. A. Wheeler; Hon. R. E. Withers, Hon. H. Clymer, General W. T. Sherman, Hon. Peter Parker, Rev. Dr. John Maclean, Dr. Henry Coppée, Dr. Noah Porter, and the Secretary, Professor Baird.

Excuses for absence on account of sickness were received from Hon. Hannibal Hamlin and Hon. Newton Booth. The minutes of the last meeting were read and approved. The Secretary presented a statement of the finances of the Institution.

Dr. Parker, Chairman of the Executive Committee, presented the annual report of the Committee, which was read.

On motion of Dr. Porter the following resolutions were adopted:

Resolved, That the report of the Executive Committee for 1880 be accepted.

Resolved, That the income for the year 1881 be appropriated for the service of the Institution upon the basis of the above report, to be expended by the Secretary with full discretion as to the items, subject to the approval of the Executive Committee.

General Sherman, Chairman of the National Museum Building Commission, presented a report of the operations of the Commission and of the Architects for the year 1880, which were read, and, on motion of Mr. Clymer, accepted.

The Secretary stated that he had been informed by the American Consul at Genoa, Italy, that the corner-posts of the railing around the tomb of James Smithson required resetting and the fence straightening, and he asked authority to have this done.

On motion of General Sherman it was

Resolved, That suitable measures be taken by the Secretary for the repair and preservation of the tomb of Smithson and its inclosure.

The Secretary presented his annual report of the operations, expenditures, and condition of the Institution for the year 1880, which was read in part.

On motion of General Sherman it was

Resolved, That the annual report of the Secretary be accepted and transmitted to Congress.

Dr. Coppée offered the following resolution, which was adopted.

Resolved, That the thanks of the Board of Regents are due and are hereby presented to Mr. William J. Rhees, the Chief Clerk of the Institution, for the excellent, accurate, and interesting manner in which, under the direction of the Secretary, he has collated and edited the volumes entitled, respectively,

1. "The Smithsonian Institution; documents relative to its origin and history."
2. "Journals of the Board of Regents, reports of Committees, Statistics, &c."
3. "The Scientific Writings of James Smithson."
4. "James Smithson and his bequest."

Hon. Mr. Withers made a statement, by request, in regard to the Virginia securities, and on motion of Mr. Clymer it was

Resolved, That the Executive Committee may at their discretion dispose of the Virginia securities owned by the Institution, to wit: 58 consolidated bonds, Nos. 11521 to 11578, inclusive, for $1,000 each; 1 consolidated bond, No. 1380, for $500; 2 consolidated bonds, Nos. 4191 and 4192, for $100 each; 1 deferred certificate, No. 4543, dated July 1, 1871, for $29,375.07, and 1 fractional certificate, No. 2969, dated July 1, 1871, for $50.13; and deposit the proceeds in the Treasury of the United States as a part of the permanent fund, as authorized by the act of Congress of February 8, 1867.

Resolved, That Spencer F. Baird, Secretary of the Smithsonian Institution, be, and he is hereby, authorized, in person or by attorney, to transfer to any person or persons the certificates of debt of the State of Virginia now standing in the name of the Regents of the Smithsonian Institution, to wit: Deferred certificate, No. 4543, dated July 1, 1871, for $29,375.07, and fractional certificate, No. 2969, dated July 1, 1871, for $50.13.

The Secretary stated that several applications had been received for the use of the new Museum after the inauguration of the President on the 4th of March next, which had been referred to the Executive Committee.

The point of order was raised that the applications could not be entertained, the Board having already decided that the use of the building was to be granted only for the inaugural reception of President Garfield.

The point of order was sustained by the Chancellor.

The Board adjourned at 12:30 P. M., *sine die.*

REPORT OF THE NATIONAL MUSEUM BUILDING COMMISSION FOR 1880.

WASHINGTON, D. C., *January* 15, 1881.

To the Board of Regents of the Smithsonian Institution:

GENTLEMEN: At your annual meeting on the 19th of last January, the National Museum Building Commission submitted a report of operations in connection with the new building for the National Museum, from their inception to the close of 1879.

In that report attention was called to the necessity for increased accommodations for the national collections in charge of the Smithsonian Institution; to the endeavors of your Board in previous years to obtain from Congress an appropriation for the same, and to their final success in 1879 in securing an appropriation of $250,000 for the purpose.

Mention was also made that the Executive Committee of the Board of Regents and the Secretary of the Institution, who are charged by resolution of the Board of January 17, 1879, with the duty of "carrying into effect the provisions of any act of Congress that might (may) be passed providing for the erection of a building for the National Museum," had organized under the title of "National Museum Building Commission."

Also, you were informed of the action of the Commission in early adopting such measures as appeared to it best calculated to realize with the least possible delay the intention of Congress in making provision for a new building; of the employment of Messrs. Cluss & Schulze as superintending architects; of the acceptance by General Meigs of the invitation of the Commission to act as its consulting engineer; and of the opinions of Mr. Edward Clark, Architect of the Capitol, and General Meigs as to the sufficiency of the appropriation for the erection of a building in accordance with the plans approved by Congress. Reference was also made to the action of the Secretary of the Treasury in detailing an officer of the Treasury Department to disburse the appropriation, by which action the fund was made immediately available. In addition, a *resumé* was presented of the active operations in the construction of the building whereby you were made aware that ground was broken on the 17th of April, 1879; that the concrete foundations were begun April 29; that the brick work of the walls was commenced May 21, and that the walls were completed on the 1st day of November.

Moreover, mention was made of the good fortune of the Commission in securing exceedingly favorable contracts, especially for the brick and iron work, previous to the early subsequent rapid advance in the prices of iron and other building materials; of the fact that the cost of the heating apparatus was not included in the estimate of $250,000, and that therefore an appropriation of $25,000 for this item had been asked of Congress; and, finally, of the then pending efforts of the Commission to settle the question of material for the cases, whether this should be wood or iron.

Besides information upon the points above specified, an appended report of the architects presented an interesting technical and descriptive record of the plan and design of the building and a detailed exhibit of the expenditures on account of construction to the close of the year 1879. In the present report, therefore, it is only necessary for the Commission to review the operations of the year just ended.

The iron work of the roofs was satisfactorily completed by the latter part of March, and the tin work and slating early in April.

The plastering, which was done partly by day's work and partly under contract, was begun early in March and finished by the latter part of July. The plaster of the slate roofs is laid directly on the slate, and that of the low, flat roofs on gratings fastened between the iron girders of the roof and rendered fire-proof by a filling of mortar composed of plaster of Paris and ashes—a form of ceiling suggested by General Meigs.

The painting and glazing has been satisfactorily done. In the interest of economy in heating, it was decided to put both an inner and an outer glass in the sash of all *outside* windows.

The supply-pipes for water and gas were laid by the close of February and the work duly inspected and approved.

The wood floors have all been put down, excepting in the four square halls. In the four main halls, or naves, and in the rotunda of the dome it was originally intended to lay concrete, but owing to urgent remonstrances against the use of this material as not being in keeping with the architectural beauty and design of the building, Congress has been asked for an appropriation of $25,000 to defray the expense of a marble or tile floor for these halls. The request for this appropriation was in accordance with a resolution of the Board of Regents of December 9th, 1880.

The heating apparatus is also in, and, with the exception of bronzing a number of the radiators, Messrs. Baker, Smith & Co. have completed their contract for this work. During the recent severe weather the apparatus was subjected to a test more severe than will be likely to occur again for a number of years, and it is a matter of congratulation to the Commission, as well as to the contractors, that the work gives entire satisfaction.

A most economical arrangement connected with this heating apparatus is that of two automatic traps whereby the condensed steam is again brought to the boilers. While by this arrangement both time and fuel for heating fresh water are saved, the fear of a lack of supply of water to the boilers is eliminated, that originally used sufficing for at least seven days.

The work of putting in the wires for the burglar-alarm telegraph, telephone, and electric clocks and call-bells, which was begun in the summer, is now nearly finished. These wires, which are run through underground trenches, either specially constructed for the purpose or for heating-pipes, will extend from a room in one of the north towers to each window, door, and case in the entire building, and also to the police and fire-alarm telegraphs. This electrical arrangement will constitute a valuable feature in the economy of administration of a structure so immense as, and of the peculiar construction of, the new Museum building, since it will lessen the necessity for a large corps of watchmen and attendants, the locality of any attempt on the part of designing persons to open a window, door, or case being at once automatically indicated in the central office, or instrument room, where a watchman will be on duty at all hours.

As the original estimates upon which the appropriation of $250,000 was based did not include a provision for the expanded system of water and gas fixtures and electrical apparatus, an appropriation of $12,500 was requested therefor and readily secured.

In addition to the above, an appropriation of $1,000* was secured for a sewer to connect with the B street sewer to relieve the building from water, which, on account of the inadequacy of the Seventh street sewer, during heavy rains, backs up in the pipes and floods the cellars. This relieving sewer will be constructed under the supervision of the engineer of the District of Columbia, Lieutenant Hoxie.

For fuller information, however, the Board is respectfully referred to the appended report of the superintending architects, which also presents a detailed exhibit of expenditures.

During the year past the Commission has met as often as was deemed necessary. General Meigs, as consulting engineer, has generally been present at the sessions of the Commission, while, as during the previous year, his visits to the new building have been frequent and his inspection of the work close and critical.

In closing this report the Commission is happy to state that the building, with the erection of which it was charged, is substantially finished, and that it hopes at the next annual session of the Board to be able to congratulate the Regents on its entire completion and occupation.

Respectfully submitted.

W. T. SHERMAN,
PETER PARKER,
SPENCER F. BAIRD,
National Museum Building Commission.

WASHINGTON, *January* 18, 1881.

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*This has been increased to $1,900 in accordance with the revised estimates of the engineer of the District.

REPORT OF THE SUPERINTENDING ARCHITECTS OF FIRE-PROOF BUILDING FOR NATIONAL MUSEUM, 1880.

WASHINGTON, D. C., *January* 1, 1881.

To the National Museum Building Commission, Smithsonian Institution, Washington, D. C.:

GENTLEMEN: We have the honor to report to you the completion of the new building under the appropriations available for the purpose, and simultaneously to submit a report of operations on the construction of the building since January 1, 1880, the date of our last report.

The progress of the work was such that the plastering of the building could be commenced as soon as the state of the weather permitted it, in the early part of the spring. It was completed by the middle of August, and, after this, miscellaneous work for finishing, such as iron balconies, railings, and stairways, were put up, all the offices were floored and put in readiness for occupation, the cellars were laid with asphaltic concrete, the wooden floors of all the outside halls were laid upon a solid bed of hydraulic cement-concrete, and a concrete base was laid for the floors of the main and square halls. All the numerous details of the steam-heating apparatus were attended to so that steam could be put on with the advent of the cold weather; and though the heavy walls and piers were considerably chilled by long-continued exposure during the early fall and the excessive moisture in the unfinished building, a comfortable heat was obtained within a few days and was maintained during the coldest days of this unusually severe winter, no more than a reasonable amount of fuel being used for heating the vast space of about 3,500,000 cubic feet inclosed within the walls and roofs of the building.

The asphalt facing of the floors of the main halls and rotunda, as intended under the estimates, has not been put on, since with hardly any difference of opinion it was held that nothing less than a chaste tiling would do justice to the building, and provision ought to be made for this without delay. On the other hand, much more than an equivalent of the cost of this surfacing has been spent on work not included in the estimates, but deemed more important for the opening of the building at as early a date as possible.

The approaches to the building, for which always a separate estimate is brought before Congress, have been mostly finished under the original appropriation. We may be allowed to state a few of the items not originally contemplated, but included in the construction accounts, to wit:

The windows in exposed walls were set with two sheets of glass for each pane, and an improved skylight for photographer was put up at a cost of...........................	$1,965 00
Three more cellars than originally contemplated were constructed, and annexes to the corner-pavilions, involving	

expensive fire-proof floors, were fitted up, the lofts in the corner-pavilions were converted into additional finished stories at a cost of	$4,500 00
The covered spaces in front of and sheltering the four main entrance doors were inclosed by ornamental iron gates at a cost of	1,804 08
All the brick work of the extensive façades was oiled and penciled at a cost of	2,750 00
Terraces were formed to regulate the grades of the ground around the building at a cost of	2,428 00
There was expended for cut stone on the approaches to the main entrance	1,286 00
Total	$14,733 08

The conditions imposed upon us to keep within the appropriations have been complied with in good faith. A substantial fire-proof building has been completed at a less cost per square foot of the inclosed area than that of the temporary buildings erected for the International Exhibition in Philadelphia in 1876.

The principle adopted to have all the windows in side walls and lanterns glazed with two sheets of glass, having an intermediate air-space, has led to favorable results, and it is desirable to extend the same feature over the under sides of the roofs in the halls by the introduction of light iron ceilings about 1½ inches distant from those plastered undersides; the intermediate air-space in this case to be packed with a non-conducting fire-proof material, such as mineral-wool or its equivalent. This will secure for the building a very pleasant temperature in summer, reduce the expense of heating the huge building in winter, and remove any tendency towards condensation on those exposed undersides during the rapid changes of temperature and hygrometric condition of the atmosphere peculiar to this climate and locality.

Having given a technical description of the design and construction of the new building in our last report, we now report specially on the theory, practice, and results of warming the building. In consideration of the great cubic contents of air inclosed in the building, and the comparatively very few sources of vitiation of the same, the system of heating by direct radiation has been adopted. For winter ventilation the spires of eight towers and the lanterns of halls and dome are made available whenever necessary, and for summer ventilation a sufficient number of improved iron sashes pivoting in iron frames have been added and inserted in the windows of the side walls and the lanterns of the building.

The heating coils and radiators are placed in the rooms to be warmed and heat the air by contact with the radiators; the surrounding walls and solid objects absorbing a certain amount of radiant heat and again heating the air by contact.

To ascertain the demands to be made upon the apparatus for heating, the conditions of the building were studied, in order to arrive at the loss of heat inside the building for an external temperature of zero and an internal temperature of 70° Fahrenheit. This loss of heat is caused by the exposed surfaces of the building, which consist of hollow brick walls plastered inside, of tin roofs lined with felt and supported by non-conducting fire-proof material plastered inside, and of windows having two thicknesses of glass with inclosed air-space. It is increased by an amount due to leakages, absorption of heat by the soil, transfusion of air by the opening of doors, &c. To allow for contingencies, the required heating surfaces resulting from above causes were increased by about fifteen per cent. and the generating power of steam three times.

The necessity for such a disproportionate amount of generating power is explained by the fact that the condensation is enormous when the steam circulating pipes and radiators are first heated up, because their specific heat is very high when compared with that of the air. When the circulation is once established, the demand upon the boilers decreases to an amount equal to the heat radiated and carried off by the air from the heating surfaces, provided that the main circulating (or flow) pipes, which are not to act as radiators, but rather as vehicles to carry the heat to the most extreme points of the building, are protected by a sufficient coating of non-conducting material, which should be provided for, the sooner the better.

It is evident that for such nice adjustments there were no funds available so far.

Continued satisfactory heating by the direct radiating system demands, with such an extensive apparatus, constant and close attention; otherwise there will be a great waste of fuel in mild weather, and well-founded complaint of overheating.

As the building is heated up, radiators must be shut off until no more heating surface is left than is required to balance the loss of heat, which in this climate is very variable. The offices require more heat, relatively, than the halls; and if, after the building is warm throughout, steam were shut down entirely to prevent overheating the halls, as would happen in mild weather, the offices could not be occupied for want of heat long before the first sensation of coolness appeared in the halls. The cause of this is that the ratio of cooling surface to space (or cubic contents) is much greater in the case of the small rooms than in the halls, which form a huge reservoir of heat, contained in the inside walls and objects as well as in the air.

It is necessary to put the whole force on once a day in order to get circulation of steam throughout. In mild weather shut down as soon as overheating begins. In extremely cold weather the full force is to be kept up continuously.

It being established by experiment that about 25 per cent. of the entire heat absorbed in evaporating the water in the boilers will be restored by returning the water of condensation in the coils to the boilers, at a temperature of about 175 degrees, instead of heating new supplies of water from an average winter temperature of 56° to the boiling point, special efforts were made in this direction. In order to prevent clattering and noise the steam-pipes have a fall *from* the boilers, so that any condensed water flows in the same direction with the steam and not against it, until points are reached where the steam-pipes are tapped and discharge the condensed water into the return pipes, which are started at the extreme end or lowest point of the flow-pipes with an adequate fall *towards* the boilers.

The extreme length of each of two lines of steam-conducting and return water-pipes is about an eighth of a mile.

To promote the usefulness of the building, these whole systems of pipes were buried in large-sized underground ducts. The grade of the public sewers does not allow the boilers to be set deep enough for returning the condensed water to them exclusively by gravitation, as is most desirable, hence it is conducted into a receiver located on the floor of the boiler-room, from which it is raised by automatic steam-traps located above the boilers. These traps are, firstly, supplied with steam from the boilers. They are so constructed that by the movement of a lever connected with a float the steam is shut off, when it condenses in the traps, causes a partial vacuum, and lifts the water from the receiver into the traps by suction. As the ascending water fills the traps it lifts the float, the lever of which gradually opens the steam-valve, permits the steam to enter the traps, and at the same time causes an equalization of pressure in the boilers and traps whereby the water, by gravitation, flows back into the boilers. To operate these traps no more pressure is required than sufficient to raise the water from the receiver to the trap.

Since immediately after starting the fires the pressure in the boilers may be too small, a steam-pump is at hand by which the water is forced direct from the receiver into the boilers. This pump works with less than two pounds pressure per square inch, and forces either hot or cold water. When a fresh supply of water should be desired and the steam-pressure is greater than that in the main water-pipes, the pump is connected with these mains and the boilers supplied therefrom. Ordinarily the boilers are fed direct from the water mains.

The steam for warming the building is generated in four tubular boilers of 56 inches diameter and 15 feet length, containing each 72 tubes of 3 inches diameter. The heat of the fire passes first under the whole length of the boilers, then back through the tubes and finally over the top of the boiler, giving the greatest possible exposure of surface and resulting in the greatest attainable economy of fuel.

The boilers are connected overhead by steam-pipes of 5 inches diameter from each, with stop-valves; these lead into a drum of 12 inches diameter to which two 8-inch main steam-pipes are attached, each of which supplies a pipe system warming one-half of the building. Valves are placed in those 8-inch pipes, and the whole apparatus is arranged so that one, or all, or any number of the four boilers can be used at pleasure and steam shut off from either half of the building, or from any desired number of the radiators. The steam-conducting pipes are gradually reduced in size, as the several branches for the supply of the radiators are taken off until at the ends of the lines at the northeast corner of the building, which is most remote from the boiler-room, the pipes have but 2 inches diameter.

The return water-pipes begin at this remote corner with 1½ inch diameter and are gradually enlarged as they receive the water of condensation from radiators and mains until they terminate in the receiver in the boiler-room as above described.

Rising lines of pipes for warming the offices of the second and third stories are attached to the horizontal piping, with suitable return-and-relief and air-valve pipes.

The best provision is made in all lines of pipes for expansion and contraction by offsets, angles, or expansion joints, as the case requires.

The horizontal pipes are mainly supported on rollers. All joints of pipes and fittings are made without the use of red lead or cement, the threads being all tapered and exactly fitted so as to be tight when simply screwed together, iron into iron.

Branch pipes extend out from the main pipes, and to these the valves and pipes of 204 upright radiators are screwed. These are all finished in bronze, and contain in the aggregate 13,600 square feet of radiating surface, which give out the heat generated in the boilers.

The efficiency of the heating apparatus, though evident, was tested by a series of observations made during the coldest weather of Christmas week.

During the daytime, with the outside temperature at an average of 5° below zero, the interior temperature did not fall below 62½° above zero when but three of the four boilers were in use, the pressure of steam being not above 12 pounds, and the consumption of coal 7,500 pounds, for twenty-four hours.

Observations were also made during the night-time, after all heat had been purposely cut off from the building and the fires banked, with the mean external temperature at 11½° below zero, the temperature within the building did not fall below 48° above zero. This is a creditable result for the yet incomplete provisions taken against losses of heat by the exposed surfaces.

The observation is also most gratifying that there is hardly any difference between the temperature on the main floor and that of the galleries and occupied higher parts of the building abutting on the halls.

Thanks to the prompt and efficient co-operation of Col. Thos. L. Casey, the engineer in charge of public grounds, the roads and lawns leading to and surrounding the building were speedily adapted to new grades and verdure restored.

FINANCIAL STATEMENT.

The appropriations made by Congress are:

For construction of building	$250,000 00
For steam-heating apparatus	25,000 00
For electric work, plumbing, &c	12,500 00
	287,500 00

Schedule account of expenditures and of liabilities, January 1, 1881.

Earthwork:		
Excavation and grading	$853 68	
Forming terraces	2,428 56	
		$3,282 24
Foundations:		
Concrete	3,899 02	
Rubble-stone masonry	7,010 64	
		10,909 66
Brick-work:		
Bricks	39,726 98	
Mortar	6,111 36	
Labor of laying bricks	26,668 96	
Centers, sheds, foremen, &c	2,376 48	
Oiling fronts, material, and labor	2,753 58	
		77,637 36
Cut-stone work:		
Of building proper	10,105 10	
Of approaches	1,286 32	
		11,391 42
Wrought and cast iron work:		
Cost of and setting floor-beams	3,822 81	
Contract for roofs, steps, and railings	37,368 89	
Anchors, hoop-irons, and miscellaneous work	4,882 60	
Four double entrance gates, including models and hanging	1,804 08	
Models of candelabras	160 00	
		48,038 38
Galvanized iron work		6,784 18
Roofing:		
Slate, slating, snow-breaks, &c	6,597 65	
Fire-proof gratings under metal roofs	12,682 27	
Manilla felt	1,145 96	
Copper gutters	1,169 68	
Tin, labor, and spout-guards	5,941 87	
		27,537 43
Concreting floors of offices and halls		6,065 29
North vestibule laid with encaustic tiles		134 20

Carpenter work and lumber:		
Window frames and sash, including hanging	$6,996 05	
Doors	2,298 25	
Flooring, sleepers, and miscellaneous lumber	4,847 62	
Nails, screws, &c	711 36	
Labor	3,591 55	
Flag-pole, set in place	61 45	
		$18,506 28
Plastering		16,781 94
Glass and ventilators:		
Plate glass	210 67	
Double-thick cylinder	3,302 57	
Ornamental cathedral glass	450 40	
Photographers' skylight	315 00	
Ventilators	444 00	
		4,722 64
Painting and glazing, including material and labor		6,677 99
Plumbing and drainage:		
Connection with main sewer	366 77	
Water supply and closets for building purposes	516 78	
Terra-cotta sewers, and cast-iron drain pipes for roofs	2,453 08	
Drainage of boiler-room	510 81	
Water-pipe and street-washers	1,344 96	
Gas-mains, service-pipe, &c	2,650 44	
Plumbing in office building	509 33	
		8,352 11
Group of statuary on main gable		2,035 05
Miscellaneous expenses:		
Survey of grounds, clearing of site, and repairing roads	1,205 55	
Printing, advertising, and photographic expenses	1,840 12	
Scales, tools, sheds, for various purposes	1,125 91	
Clerical expenses and watchman	5,144 60	
Stationery, office furniture, traveling expenses, telegrams, and incidentals	1,046 21	
		10,362 39
Construction and superintendence		10,000 00
Steam-heating apparatus		17,268 00
Brick-work, excavations, &c		113 80
Electrical apparatus		822 31
Total		287,422 67

Of this sum there has been actually expended	$283,449 67
Outstanding liabilities under agreements	3,848 00
Balance available (after meeting all liabilities) January 1, 1881	202 33
	287,500 00
Add appropriation for sewer in hands of disbursing agent	1,000 00
Balance unexpended (but of which $3,848 is unavailable on account of liabilities)	4,050 33
Total balance, January 1, 1881, in hands of Major Hobbs, disbursing agent	5,050 33

We have the honor to be, gentlemen, your most obedient servants,

CLUSS & SCHULZE,
Architects.

GENERAL APPENDIX

TO THE

SMITHSONIAN REPORT FOR 1880.

ADVERTISEMENT.

The object of the General Appendix is to furnish summaries of scientific discovery in particular directions; occasional reports of the investigations made by collaborators of the institution; memoirs of a general character or on special topics, whether original and prepared expressly for the purpose, or selected from foreign journals and proceedings; and briefly to present (as fully as space will permit) such papers not published in the "Smithsonian Contributions" or in the "Miscellaneous Collections" which may be supposed to be of interest or value to the numerous correspondents of the Institution.

RECORD OF SCIENTIFIC PROGRESS.

INTRODUCTION.

While it has been a prominent object of the Board of Regents of the Smithsonian Institution from a very early date in its history to enrich the annual report required of them with scientific memoirs illustrating the more remarkable and important developments in physical and biological discovery as well as the general character of the operations of the Institution, this purpose has not hitherto been carried out on any very systematic plan. Believing, however, that an annual report or summary of the recent advances made in the leading departments of scientific inquiry would supply a want very generally felt, and would be favorably received by all those interested in the diffusion of knowledge, the Secretary has had prepared by competent collaborators a series of abstracts showing concisely the prominent features of recent scientific progress in astronomy, geology, physics, chemistry, mineralogy, botany, zoölogy, and anthropology. Other subjects which might properly have been included, such as those of terrestrial physics and meteorology, geography and hydrography, microscopy, &c., as well as the more practical topics of agricultural and horticultural economy, engineering, technology, and industrial statistics have, for the present, been omitted, both for want of time in which to have them properly digested and for want of space to allow them any sufficient presentation. With every effort to secure prompt attention to all the more important details of such a work, various unexpected delays frequently render it impracticable to obtain all the desired reports in each department within the time prescribed. In such cases it is designed, if possible, to bring up such deficiencies and supply them in subsequent reports.

A similar digest, having the title of "Annual Record of Science and Industry," prepared under the general editorship of the present Secretary of the Institution, was commenced in 1871, and published in a duodecimo form by the Messrs. Harper, of New York.* This work was continued through eight annual volumes; but was discontinued with the volume for 1878. The present undertaking may, therefore, be considered as in some sense a continuation of the work published by the Messrs. Harper.

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* The "Annual Record of Science and Industry" was itself a successor to a similar year-book entitled "The Annual of Scientific Discovery" commenced in the year 1850 under the editorship of Mr. David A. Wells, and published by Messrs. Gould and Lincoln, of Boston. The last-mentioned work was satisfactorily continued for sixteen years, from 1850 to 1865, inclusive, when it was suspended by the appointment of its editor, Mr. Wells, to the commissionership of internal revenue under the United States Treasury Department. The work was, however, resumed in 1867, under the editorship of

It is scarcely necessary to remark that in a résumé of the annual progress of scientific discovery so condensed as the present, the wants of the specialist in any branch can be but imperfectly supplied; and very many items and details of great value to him must be entirely omitted. While the student in a special field of knowledge may occasionally receive hints that will be found of interest, he will naturally be led to consult for fuller information the original journals and special periodicals from which these brief notices or abstracts have been compiled.

The contemplated plan of devoting some 250 pages of the annual report to such a compilation is not designed to preclude the introduction into the "General Appendix," as heretofore, of special monographs or discussions that may prove interesting to the scientific student.

SPENCER F. BAIRD.

Dr. Samuel Kneeland, who conducted it for the years 1867, 1868, and 1869. It then passed under the editorship of Prof. John Trowbridge, for the years 1870 and 1871, when it was finally discontinued, and the "Annual Record of Science and Industry" took its place.

ASTRONOMY.

BY PROF. EDWARD S. HOLDEN.

INTRODUCTION.

As the space available for the record of astronomical progress is comparatively small, the accounts here given must necessarily be the barest summaries, whose chief end is to call attention to work which has been done, in order that a reference may be made to more extended papers if desired. At the same time it is clearly impossible to give a specific reference to each of the papers consulted.

For such bibliographic information the reader is once for all referred to DARBOUX et HOUËL'S *Bulletin des Sciences Mathématiques et Astronomiques* (monthly, Paris), to *Nature* (weekly, London), to *Science* (weekly, New York), to the *Observatory* (monthly, London), and to other standard journals. Free use has been made of reviews by writers in these and other periodicals, particularly of the *Record of Astronomy*, published by Dr. J. L. E. DREYER in the Scientific Proceedings of the Royal Dublin Society.

NEBULÆ AND CLUSTERS.

The Earl of ROSSE has published Parts 1 and 2 (0^h to 14^h R.A.) of the "Observations of Nebulæ and Clusters of Stars made with the six-foot and three-foot reflectors at Birr Castle from the year 1848 up to about the year 1878" (Trans. R. Dublin Soc., Vol. II). This publication (of which the third part, comprising the last ten hours of R.A., is in the press) embodies all the work done on nebulæ since the erection of the six-foot telescope in 1845. In 1850 and 1861 abstracts of the observations on more interesting objects appeared in the Philosophical Transactions, but all these abstracts are given over again in the new publication, with the sole exception of the copperplate engravings, to which, however, in all cases references are made in the text. Though even now not every single note in the observing ledgers is published, nothing has been suppressed which can be of the slightest value or importance. The observations are given in the observer's own words, and the notes which were added by Mr. DREYER while arranging the work for publication are easily distinguished by being inclosed in brackets. These notes deal especially with questions of identification, and nearly all the new nebulæ which were found at Birr Castle in the course of years and which formed the weak point of **Herschel's** General Catalogue, have now by re-examination and comparison with **D'Arrest's** observations been identified and their positions determined. The work done during the last five or six years (1872–'78) differs in many particulars from the observations taken in earlier years, with which the paper of 1861 made the scientific world acquainted. Most of the more important nebulæ having been frequently drawn, there was latterly not much to be done in this direction, but another important field was opened up by taking micrometric measures of groups of nebulæ, or of nebulæ and neighboring stars. Into the text have been introduced diagrams of such groups or of a nebula and the stars near it, while four plates contain lithographic reproductions of more elaborate sketches, which had not already been published among the engravings in the former papers. How much more detail is given in the new publication than in the paper of 1861 may be seen from the circumstance that while the fourteen hours of R.A. in the latter only cover 34 pages, in the new paper they extend over 129 pages.

A series of measurements of all the planetary nebulæ has been commenced with the 15-inch refractor of the Harvard College Observatory.

Dr. C. H. F. **Peters** has lately published in *Urania* an important list of nebulæ found on his ecliptic charts.

Photographs of the Nebula of Orion.—Prof. **Henry Draper** distributed in 1880 a large number of photographs of the nebula in Orion, taken by means of his 11-inch Clark refractor with an exposure of 51 minutes. Stars down to the 10th magnitude were shown and the details of the more prominent masses of the central and brightest regions were for the first time permanently and automatically registered. The work so well begun has been brilliantly prosecuted, and in March, 1881, Dr. **Draper** succeeded in obtaining fine photographs with an exposure of 140 minutes! These give a much greater extent to the nebulous portions registered and bring out many details, and what is astonishing they show stars whose magnitudes Prof. **Pickering** has photometrically determined to be from 14.0 to 14.7 of Pogson's scale. The *minimum visibile* of an 11-inch telescope is about 14.2, so that it really appears that Dr. **Draper** has photographed stars which are very near the limit of naked eye vision if not actually below it. The mechanical perfection of the appliances which render such feats possible can only be appreciated by those used to the apparatus furnished by the best makers, which is far inferior to that made by Dr. **Draper** for his own use.

FIXED STARS.

Fixed stars, catalogues of stars, star charts, double stars, binary stars, variable stars, etc.—Decidedly the most important recent contribution of observing astronomy is the "Uranometria Argentina*" of Dr. **Gould**.

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* "Resultados del Observatorio Nacional Argentina." Vol. I, "Uranometria Argentina," Buenos Aires, 1879, 4to, with atlas.

This is the first astronomical publication of the national observatory of the Argentine Republic.

One of the first objects of Dr. GOULD, on the establishment of the new observatory in 1870, was the making of a uranometry of the southern sky, which should contain the position and magnitude of every star visible to the naked eye at his station.

The model on which it is made is the celebrated "Uranometria nova," of ARGELANDER, of Bonn, which was published in 1843. The latter contains 3,256 stars from the first to the sixth magnitude, which are to be seen above the horizon of Bonn. Its magnitudes are expressed in *thirds* of a whole magnitude, and ARGELANDER'S scale, so established, has served for a standard in all the observations in the northern hemisphere. Dr. GOULD'S problem was to extend this enumeration over the whole southern sky, keeping accurately to the standard set by ARGELANDER. This is by no means an easy task, as the *minimum visibile* at Cordoba was found to be not the 6.0 magnitude, but 7.1; that is, stars can still be seen at Cordoba which have less than four-tenths of the light of the faintest of ARGELANDER'S stars. This extraordinary transparency of the atmosphere required the extension of ARGELANDER'S scale downward, and that this was accomplished successfully is shown by a comparison of the magnitudes of all the stars which are common to the two uranometries. The mean difference is rather less than one-tenth of a magnitude. The method of settling the standard was to select from the "Uranometria nova" a belt of stars which had the same altitude at Bonn and at Cordoba. The 722 stars of this belt were observed by the four assistants at the southern observatory (Messrs. ROCK THOME, DAVIS, and HATHAWAY), and those stars for which their estimated magnitudes were precisely the same were chosen for standards. Thus, a number of stars of each magnitude, as 3.00, 3.33, 3.66, 4.00, 4.33, etc., became types to be constantly referred to. From these types a number of others in a zone near the south pole (and hence constantly visible) were constructed. The process of observation consisted in referring each star in the heavens to this set of types, so that its magnitude could be finally determined upon. This was done by the four observers independently, but often in duplicate, and so well were the standards fixed that each observer's comparisons differed from the mean of all four by quantities very much less than a tenth of a magnitude. It should be said that the magnitudes in the southern uranometry are given to tenths.

In all there are 10,649 stars visible to the naked eye at Cordoba. Of these, 8,198 are as bright or brighter than the 7.0 magnitude, and these alone are given in the catalogue and in the maps. Of these 10,000 stars more than 46,000 observations were made. In the progress of the work quite a number of variable stars were detected, of each of which a full history is given in the notes. Indeed Dr. GOULD'S firm conviction is that "stellar variability is by no means an exceptional phenomenon, but that at least one-half of the stars above the 7.0 magnitude vary by amounts which careful observation cannot fail to detect."

An atlas of fourteen charts accompanies the catalogue, and gives an exact pictorial representation of the state of the sky at the epoch of the work. Besides giving a representation of the isolated stars, the shadings and gradations of the milky way are given with the greatest detail from repeated observations and revisions. By no means the least valuable part of the work is the discussion of the course of the milky way throughout the whole sky. The course of the galaxy is now, and only now, known with precision. The data of this and preceding uranometries are discussed by Dr. GOULD with reference to the question of the distribution of the stars in space, starting from the assumption that, on the whole, stars are equally scattered. Dr. GOULD finds that there is a marked excess of the stars from the first to the fourth magnitude Furthermore, he finds that there is in the sky a zone or belt of bright stars as marked as the milky way, and that all the bright stars are distributed more symmetrically with respect to this belt than with regard to the milky way itself. From these facts Dr. GOULD concludes that "our own solar system forms a part of a small cluster distinct from the vast organization of that which forms the milky way." This cluster may perhaps be comparable with that of the Pleiades, since by a rough estimate it would seem to consist of about 500 stars. It is situated nearly in the plane of the belt of bright stars.

No more valuable work than this has been given to astronomy within the decade; and it will be a source of pride to Americans to find such important contributions coming from one of their countrymen in the southern hemisphere, with which the name of GILLISS was already indissolubly associated.

There are no marks about the work itself which would show that it was done in a community in about the state of Europe during the dark ages, and it will add, not to the value of the work, but to the credit of the workers, if one remembers that this is strictly the case.

Dr. AUWERS has published, for the zone committee of the Astronomische Gesellschaft, an important work, "Fundamental Catalog für die Zonen-Beobachtungen am nördlichen Himmel." (Leipzig, Engelmann, 4to.) This catalogue of 539 stars, on which the places of all the stars between —2° and +80° Decl. down to the 9th mag. inclusive will depend, is founded on the following systems of standard places: Pulkova, 1845 and 1865; MS. of Pulkova Observations, 1869–'74; MS. of Bradley's Stars from Greenwich Observations 1836–'72 on the system of the first 7-year Catalogue; Greenwich 9-year Catalogue; Harvard College Observatory, vol. x; Engelmann's Declinations, 1866–'70; Leiden Declinations, 1864–'70.

At the Berlin meeting of the Astronomische Gesellschaft reports on the zone observations were read. The following account is taken from Dr. **Dreyer's** report. Much progress has been made since then.

° °
80–75. Kasan. Observations finished, except a few; reductions far progressed; printing commenced.
75–70. Dorpat. Only 920 observations yet to be made; more than half the reductions to 1875.0 finished.
70–65. Christiania. Zones finished; about 90 per cent. reduced.
65–55. Gotha (formerly Helsingfors). Zones finished; reductions far advanced.
55–50. Cambridge, U. S. Observations finished; reductions progressing well.
50–40. Bonn. About 5,000 single observations remain to be made; reductions far advanced.
40–35. Lund. Observations commenced in September, 1878; the reductions are progressing with the zones.
35–30. Leiden. Finished.
30–25. Cambridge (England). About 4,000 single observations to be made yet. The mean places are calculated up to the end of 1874, apparent places to the end of 1876.
25–20. Berlin. Not yet commenced.
20–15. Berlin. Finished, but not yet reduced.
15–10. Leipzig. Zones finished; R. A.'s almost all reduced to 1875.0 zeros for declinations partly computed.
10–5. Leipzig. Has been commenced.
5–1. Albany. Observations were commenced in August, 1878.
+ 1 to – 2. Nicolajeff. Much interrupted by the Russo-Turkish war.

A second edition of the Washington Catalogue of Stars has been issued. Since the first edition was published in 1873, Professor **Yarnall** had accumulated many observations, which he, before retiring from the Observatory, embodied in a second edition. Many stars which had only been observed once or twice, either in right ascension or declination, were thus re-examined. The author died suddenly, on February 27, 1879, the complete volume only reaching him a few moments before his death.

Dr. **Robinson** has published "Places of 1,000 Stars, observed at the Armagh Observatory." The stars are those of the fainter ones in the "Histoire Céleste" (nearly all between 6th and 7.5 mag.), which have not been recently observed at other observatories. The instruments at Armagh not being optically powerful enough for this work, the mural circle was furnished with a new telescope having an object-glass of seven inches aperture. The observations were all made by the Rev. **Ch. Faris**, in the years 1868–'76, each star being observed four or five times. Only the mean results are given.

The first volume of the second series of the "Annales de l'Observatoire de Bruxelles" contains an "Uranométrie Générale," by M. **Hou-**

ZEAU. During a stay in Jamaica the author resolved to form a new Uranometry, which should possess the advantage above all others hitherto published, that it was to be the work of a single individual, observing all the stars in both hemispheres visible to the naked eye within a short space of time. He accordingly commenced working on January 28, 1875, and the work was finished on February 28, 1876. He had first prepared maps, on which all the stars were plotted down without regard to magnitude; then every region was gone over two or three times, and the magnitudes carefully estimated, the six usual classes being used, but each class only divided into two halves. The atlas thus formed consists of five plates, on which the stars, their letters, the names and limits of the constellations (but not their figures), and the milky way are depicted. The latter has been attended to with great care, the deeper or paler hue of the light-green color representing greater or lesser brightness. The catalogue of stars for 1880 contains 5,719 stars. M. HOUZEAU has examined the distribution of the stars in four ways: 1, with respect to the solar equator; 2, with respect to the direction of the sun's proper motion; 3, perpendicular to this direction; 4, with respect to the milky way. No law whatever was found in the first three ways, while the fourth mode of proceeding confirmed W. STRUVE'S conclusion that the density of stellar layers parallel to the plane of the milky way decreases very regularly and gradually towards the poles of the latter.

JULIUS SCHMIDT has, in continuation of his researches on the colors of stars, published an extensive series of color estimations, made chiefly with the finder of the Athens refractor, from 1872–'78. Only for Arcturus has he been able, with any certainty, to find a variation of color. It is mostly very bright stars he has observed, and he investigates the difference in the estimation, according to whether the finder or the refractor was used, and finds a greater difference the nearer the color is to white.

A "new star" of 8.8 mag. was found in November by Mr. BAXENDELL, according to two Dun Eecht observations in $7^h\ 34^m\ 45^s.67 + 8^\circ\ 39'\ 39''.6$ (1879.0). According to VOGEL, the spectrum is very remarkable, with many dark bands, especially in the more refrangible part.

PARALLAX OF STARS.

Nearly the whole of Part III of the "Astronomical Observations and Researches made at Dunsink" is devoted to annual parallax. The first paper contains a discussion of observations of the planetary nebula H. IV. 37 from August, 1871, to August, 1872, by Dr. BRÜNNOW. The nebula has in the center a well-defined point resembling a star of the eleventh magnitude. This was compared in declination with a star of the tenth magnitude, and the parallax was found to be perfectly insensible, a result which agrees well with that of a similar series of observations by Professor BREDICHIN, of Moscow.

A notice of an elaborate paper by Dr. ELKIN on the parallax of *Alpha*

Centauri must be deferred till the next year, as the paper is not now before the writer.

A new determination of the parallax of 61 Cygni, by Dr. BALL, forms the subject of the next paper. This determination differs from others on the same object in one particular, viz, that the preceding star instead of the following one has been observed. The method of observation used is that of differences of declination, and the observations were made on thirty-five different nights between July 3, 1877, and June 1, 1878. The resulting parallax is 0″.465, in pretty good accordance with the results of BESSEL (last three months 0″.54), STRUVE (0″.51), and AUWERS (0″.56).

A third paper, also by Dr. BALL, describes the first results of a series of reconnoitering observations in search of stars with a large annual parallax. These observations are only intended to reveal large parallaxes (0″.7) or more, and each object is only observed twice a year with six months' interval, when it is 90° from the sun, and at the two extremities of the major axis of the parallactic ellipse. The paper contains the discussion of the observations of forty-two objects, chiefly red and variable stars. The result is that in almost every case the parallax is certainly less than 1″, and most probably does not exceed 0″.5. These objects will therefore not be observed any further, but it is Dr. BALL'S intention to continue this kind of observations. His working list contains red and variable stars, stars with a large proper motion, and others chosen for various reasons, nearly all north of the 30° parallel.

According to Herr GEELMUYDEN, of Christiania, the star Arg. Oeltzen, 11677, has a perceptible parallax (A. N. 2237). This star of the ninth magnitude has a proper motion of $-0^s.507$ and $+0''.21$. The resulting parallax, 0″.27 from measures of $\triangle\alpha$ and 0″.24 from measures of $\triangle\delta$ with a star preceding, is only considered provisional, but the subject seems worth following up.

DOUBLE STARS.

In 1841 and 1842 the Pulkova refractor was used for an examination of the northern hemisphere in search of double stars. The second part of the catalogue thus formed embraces systems, the components of which are of or above the eighth mag., and the distance between which are from 32″ to 2′. Most of these objects have never been observed micrometrically, and the series of heliometer measures of some of them, which Dr. SCHUR, of Strassburg, publishes in the A. N. 2255–56, will therefore be of interest, though only comprising a small number of objects. Systems closer than 40″ were measured by quadruple distances, wider pairs by double distances. By means of an artificial pair of stars it was found that the position angle had no appreciable influence on the measures of distance, and that the two methods of measuring the distances showed no constant difference.

Volume XLIV of the Memoirs of R. A. S. contains a very extensive work by Mr. BURNHAM: "Double-star observations made in 1877–'78, at Chicago, with the 18½-inch refractor of the Dearborn Observatory, comprising: I. A Catalogue of 251 New Double Stars with Measures; II. Micrometrical Measures of 500 Double Stars."

Up to a few years ago the Dearborn refractor, with which CLARK discovered the companion of Sirius in 1862, was idle. It has, however, since, in the hands of Mr. BURNHAM, done excellent work. Confining himself to the subject of double stars this distinguished observer has, in the course of six or seven years, first working with a 6-inch, afterwards using the 18½ inch refractor, made this subject his own to an extent that is truly surprising. Though many observations are yearly being taken of double stars by a good many observers, the study of these important objects is by no means being furthered to the extent one should have expected from the vast amount of time and labor expended. As Mr. BURNHAM justly remarks, in the preface to the paper we are here considering, many observers have gone on from year to year observing over and over again the same familiar stars, of which Castor, γ Virginis, ε Lyræ may be cited as examples. Couples which small instruments of three or four inches aperture would show sufficiently well are thus again and again being observed with fine refractors of six or seven inches aperture or upwards, while a very great number of stars are hardly ever if at all looked for. "Omit the observations of DEMBOWSKI and O. STRUVE and our knowledge of nine-tenths of the double stars would not be materially advanced in the last thirty years." Mr. BURNHAM has from the beginning shown that he does not follow the ordinary beaten track, and his numerous discoveries of close and difficult pairs have proved him to be an unusually sharp-sighted and attentive observer. In nine previous lists he had given the places of 482 new double stars, mostly rather difficult pairs, which few would have discovered with a 6-inch refractor. The present (tenth) list of 251 new objects raises the total number of new double stars discovered by Mr. BURNHAM to 733; of these 251 stars, 75 pairs are less than 1″ apart. His observations of old double stars embrace chiefly such ones which require a large aperture to be brought out well, or which have not been recently observed by others. Particular attention has also been paid to certain difficult pairs discovered by Mr. ALVAN G. CLARK.

No. 5 of the publications of the Cincinnati Observatory contains "Micrometrical Measurements of 1,054 Double Stars from January 1, 1878, to September 1, 1879." Though the discovery of new double stars has only been considered a secondary object, nearly 200 new pairs have been detected during the progress of the work at Cincinnati. The measures are all given in full detail and occupy 151 pages; the mean results are given separately.

The systematic errors in measures of double stars have been investigated by Professor THIELE in a paper: "Castor, Calcul du mouvement relatif et Critique des observations de cette étoile double." (Copenhagen, 1879.) The author has chosen Castor partly because the orbital motion is slow and can be represented by a simple formula of interpolation, partly because it has been very frequently measured by almost all observers of double stars. First, three normal places were formed which represented the distances and position angles observed since 1815, and an angle of position from **Bradley's** and W. **Herschel's** measures. From these and the ratio of the sector to the time, formulæ for computing distance and position angle as functions of time by means of the eccentric anomaly were derived and an ephemeris computed from 1718 to 1900. With this ephemeris all individual observations by every observer were compared and the mean error determined for every observer within a period during which he might be supposed not to have changed his way of measuring. Every observer is now followed from one period to another and the changes in the mean error determined, whereby variations in his systematic error reveal themselves.

Dr. **Seeliger** has made an elaborate examination of **Mädler's** measures (A. N. 2288). **Mädler's** distances appear to be considerably less accurate than O. **Struve's**, while his position angles do not appear to have larger mean errors than those of O. **Struve**.

The most important series of double-star measures published since *Mensuræ micrometricæ* is that given in Volume IX of the Pulkova Observations, comprising the work of **Otto Struve** with the 15-inch refractor since about 1840. An elaborate introduction details the observations of artificial double stars and the method of applying the corrections thus obtained to the measures of real stars. Section I is devoted to the re-measurement of a large number of the most interesting of the stars forming the catalogue of the elder **Struve**. Section II contains the measures of nearly all the stars of the revised edition of the Pulkova catalogue of 1850, and about thirty additional pairs discovered subsequently (*OΣ* 515 to 547). The only other systematic observations of these stars were made by the late Baron **Dembowski** about 1860. As many of these pairs are rapid binary systems, and nearly all of them interesting from the closeness and inequality of the components, the Pulkova measures, giving earlier epochs, are specially valuable.

A valuable contribution to the literature of this department, and second to none in practical value to the observer, is **Flammarion's** "Catalogue des Etoiles doubles et multiples en mouvement relatif certain." This work contains a complete list of all double stars the components of which have shown any decided change either from orbital or proper motion, with all the published micrometrical measures down to 1878, arranged in chronological order, and notes as to the character and extent of the motion, the most recently computed orbits of binaries, etc. As a working list for the practical observer it is specially valuable, since the stars which most need observing can be at once selected.

The "Hand-Book of Double Stars," by Messrs. **Crossley, Gledhill**, and **Wilson**, published in 1879, in addition to an extensive catalogue of binary and other interesting stars by Mr. GLEDHILL, comprising altogether some fifteen hundred objects, contains chapters on the equatorial and the observatory by Mr. CROSSLEY; on methods of observing and the instruments which have been used in this work by Mr. GLEDHILL; on micrometers by Mr. CROSSLEY; on the methods of computing double-star orbits, analytically and graphically, by Mr. WILSON and Dr. DOBERCK, and the bibliography of the subject by Mr. GLEDHILL. The catalogue is conveniently arranged in order of R. A., but the measures of each star are placed opposite the names of the respective observers, an arrangement far less convenient than a simple chronological one. On the whole the work is an excellent one, and contains many valuable suggestions to amateurs, not ordinarily found in astronomical books.

Professor HOLDEN has tabulated the magnitudes and colors of 162 stars which are certainly binary, according to a list furnished by Mr. BURNHAM, and finds that of these the components of 122 binary stars of the same color differ in magnitude on the average only $0^{m.}5$, whilst those of 40 of different colors differ $2^{m.}4$. The colors and magnitudes are for the most part taken from M. STRUVE'S estimations. Professor HOLDEN quotes a conclusion by Dr. HUGGINS and Professor MILLER that the characteristic colors of stars are due to the absorptive action of their atmospheres, and compares it with the two following facts: (1) The color of a solid body cooling would as it cooled pass through the shades *white*, *yellow*, *orange*, *red*, but not through *green*, *blue*, or *purple*. (2) We do not find *isolated* stars of decided green, blue, or purple colors. A few such have been recorded, but in most cases erroneously. In general such stars are small, and apparently invariably associated with larger stars. That is, the isolated stars appear always of the colors which would arise in the cooling of solid or liquid masses, and never as if necessarily surrounded with absorptive atmospheres—*i. e.*, never decided violet or purple.

Professor PICKERING has published a paper on the Actual Dimensions of the Fixed Stars, in which the hypothesis that stars are of equal intrinsic brilliancy is made the basis of computation. While this hypothesis is perhaps as little objectionable as any general one that can be made, it still leads to conclusions which cannot be at once accepted, as has been shown by Professor HOLDEN in a paper extending Professor PICKERING'S work.

Variable stars.—For some years it has been generally received that the star *Alpha Ursæ Majoris* periodically changed its color from yellow through red to orange, etc., every thirty-two days. This supposed discovery was made in 1867, by KLEIN, and has been confirmed, or at least not disproved, by several subsequent observers.

This question is now tolerably well settled by ŜAFARIK, who has chosen three other stars to observe simultaneously with this. He has shown that the variations in *a* Ursæ are no greater than in the case of these three stars, which are pretty certainly constant in color, and he gives it as his opinion that *a* Ursæ must be considered also as of a constant color, unless we are willing to admit that all stars are variable in tint in short periods of time. This result is of more importance than at first sight appears, as we have now no well authenticated case of variation of color separate from variation in brilliance.

Dr. GYLDÉN, of Stockholm, has recently published a mathematical investigation, in which he shows the possibility of explaining the observed variation in the light of stars upon pure mechanical principles. He takes as a basis the idea that the surfaces of such stars are covered in parts with a kind of crust or *slag*, which gives out less light than the remaining parts of the surface, which are glowing. Further, he supposes these stars to be rotating on their axes, and he shows that such a rotation will account for all the phenomena, particularly as the axis of rotation will itself be changed from time to time by the different disposition of the floating masses on the surface. It is noteworthy that the possibility of such an explanation was first suggested by Sir WILLIAM HERCHEL.

THE SUN.

A new determination of the inclination of the ecliptic is contained in the doctor-dissertation by E. F. VAN DE SANDE BAKHUYZEN, of the Leiden Observatory. The author discusses the declinations of the sun observed in Leiden in the years 1864–'76, and enters into all details relating to the instrument used, etc. He finds that the inclination for 1870 as given in LEVERRIER'S tables should be diminished by about 0″.30. This result agrees well with OPPOLZER'S inclination for 1815 brought down to 1870, with a secular diminution as found by means of the latest values of the planetary masses.

A review of the new or modified theory of the constitution of the sun, proposed by Dr. HASTINGS, is necessarily postponed for want of the necessary space to detail his arguments. It may be briefly said, however, that no theory of the sun's constitution previously proposed can account for all the facts of *both* spectroscopic and telescopic observation; and it is claimed by Dr. HASTINGS with good show of reason that his hypothesis does this satisfactorily. It was published in the American Journal of Science, and will doubtless receive the consideration asked for it.

Sun parallax.—Several determinations of the solar parallax have been lately published. From his observations of Mars, made at Ascension Island in 1877, Mr. GILL finds $\pi = 8''.78$ (M.N. June, 1879). At the same opposition Mr. MAXWELL HALL, in Jamaica, made similar observations of the displacement of Mars in R. A. (Mem. R. A. S., XLIV.) He used an equatorial of four inches aperture. Mr. HALL has carefully reduced his observations, and the resulting parallax, 8″.79, indicates that valuable results may be obtained by this method by small instruments.

Observations of the declination of Mars made in 1877 at Leyden and Melbourne have been used by Mr. **Downing** to find a value for the solar parallax. The result is 8″.96 (A. N. 2283). It is remarkable how well this agrees with **Stone's** and **Winnecke's** results from the opposition of 1862 (8″.93 and 8″.96).

Vol. 1, part 3, of the "Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac," containing the experiments upon the velocity of light, made by Master A. A. **Michelson**, U. S. N., has just been published. His method of investigation (an improved form of **Foucault's** method) is described in the section on "Physics."

The final value for the velocity of light *in vacuo* is 299,944 ± 51 (in air, 299,864), or, in round numbers, 299,940 kilometers per second = 186,380 miles per second, the remarkably small error, ± 51 kilometers, being composed of the total constant error in the most unfavorable case, and the probable errors of observation. This quantity, ± 51 kilometers, cannot be said to express the *probable error* of the determination, in the ordinary acceptance of the term; combining, as it does, accidental errors, strictly speaking, and estimated constant errors.

These experiments were made by Master **Michelson** at the Naval Academy, Annapolis, at private expense, and to him the entire credit is due. A new determination of the velocity of light, embodying essentially the same arrangement, but with more elaborate and expensive apparatus, has been completed by Professor **Newcomb**, superintendent of the Nautical Almanac; and this combined with a revised constant of aberration, will give the best value of the Solar Parallax.

Transit of Venus December 6, 1882.—The Astronomer Royal has pointed out the best stations to be occupied for observations of the next Transit of Venus.

Ingress accelerated can be well observed in Cape Colony, Africa. Mr. **Gill** will soon determine his longitude telegraphically.

Ingress retarded should be observed in the West Indies. These longitudes have been determined already by officers of the United States Navy.

Egress accelerated may be observed at the West India stations and along the east coast of the United States.

Egress retarded: Stations in New Zealand are best suited, although Australian stations will serve.

SOLAR ECLIPSES.

Professor **Newcomb** has published a paper "On the recurrence of Solar Eclipses, with Tables of Eclipses from B. C., 700 to A. D. 2300"

(Washington, 1879, 4to). The theory is founded on two remarkable and hitherto unnoticed chance relations connected with the Saros. This cycle takes account only of the mean motions of the Sun and Moon, but in consequence of the eccentricity of the orbits the Sun may be 2° on either side of its mean place, and the Moon 5°. The relative position of the two bodies may therefore vary 7° from their mean position at any time, and recurring eclipses might be expected to differ widely from the predicted time, or might not occur at all. But, as a matter of fact, this is not the case, the irregularities being reduced almost to nothing by the following remarkable relations. At the end of a Saros, not only are the Sun, the Moon, and the node found nearly in their original relation, but the mean anomaly of the Moon happens to have the same value to less than 3°, and the mean anomaly of the Sun to about 12°. Therefore, not only the mean place of the Moon, but all its larger inequalities, will return nearly to their original values at the end of the period. This will hold true, not only with respect to the time of the eclipse, but also with respect to its character, as the parallax and semi-diameter of the Moon must also return nearly to their original values. On account of the retrocession of 28′.6 in the the argument of latitude in each cycle, the corresponding eclipses in successive cycles are subject to a progressive change. A series of such eclipses commences with a very small eclipse near one pole of the earth; gradually increasing for about eleven recurrences, it will become central near the same pole. Forty or more central eclipses will then recur, the central line moving slowly towards the other pole. The series will then become partial, and finally cease altogether. The entire duration of the series will be more than a thousand years, and a new series commences on an average at intervals of thirty years. All eclipses may therefore be divided into sets, the separate eclipses of each set being separated by intervals of one 18-year cycle, and extending through sixty or seventy cycles. Moreover, from the elements of the central eclipse of each set those of any other of the same set may be readily found by applying the changes corresponding to the number of intervals which separate it from the central one. This circumstance Prof. NEWCOMB has utilized to form a series of tables which give at once the circumstances of any eclipse between B. C. 700 and A. D. 2300.

Phenomena attending Solar eclipses.—The whole subject of the characteristics of solar eclipses is in so undecided a state that even those who are most familiar with it are conscious of their incomplete knowledge of the data. A general review of the evidence on special points has been well nigh impossible. Like all comparatively new problems, the different branches of the research have been developed in quite an irregular way. On some lines of research our knowledge is very considerable; on others, we have scarcely any trustworthy information.

This was specially a hindrance in the study of the phenomena of solar eclipses, because it is just here that we may hope for striking advances within a few years. And it is necessary, in order to plan our future work, to know what has already been settled, and along what lines of study results are to be sought. A recent publication of Mr. RANYARD'S, on the phenomena of "Solar Eclipses," is intended to meet these difficulties. Mr. RANYARD has collected, in Vol. XLI of the "Memoirs of the Royal Astronomical Society" (792 pages, 18 plates, and a great number of wood cuts) all the accounts of solar eclipses which have been published from the earliest times up to 1878. Each account is cut up into parts, as it were, and the matter of each part is inserted in its proper chronological order, under one of forty-four headings, chosen by Mr. RANYARD with great care. Each heading constitutes a chapter, and the chapters are arranged about in the order in which the phenomena of which they treat occur. Thus the chapters relating to the phenomena near first contact have for titles: Chapter VII. "The Cusps of the Solar Crescent seen as colored." Chapter VIII. "The Moon seen as red before Totality." Chapter IX. "Shadow-Bands;" etc., etc. Perhaps the most important chapters are numbered XLI, XLII, XLIII, XLIV: On "The Brightness of the Corona," on "Polaroscopic and Spectroscopic Observations," and on "Photographs and Drawings of the Corona," respectively. The last chapter consists of 238 pages, and contains a reproduction of every important modern drawing. A very good feature of the wood cuts is that the axis of the sun is made vertical on the page, and the sun's vertex is marked also. The plates relate to the spectrum of the corona, etc., and to the photographs, etc., of the total phase. We are glad to notice that due credit is here given to Dr. BUSCH, who first took a daguerreotype of the corona in 1851, at Königsberg. The very varied material contained in the volume is made available by an elaborate subject and author index, and the chief problems which Mr. RANYARD set to himself are resolved. These were: 1. To give in the order of time all of the important observations on each of the main topics of study; 2. To enable the work of any particular individual to be examined; and, 3. To enable each solar eclipse to be studied by itself if desired.

The work has required about nine years for its preparation, and is practically complete. We have simply to add to the data there given, and need never go back of it. In general there is no complete discussion of the results to be derived from each chapter, and this reserve seems wise. In some cases the necessary conclusions are pointed out, always, it seems, with moderation. It is an unfortunate consequence of this kind of semi-bibliographical work that it will be severely criticised. Each chapter will appear inadequate to the specialist in the subject of which it treats. There can be no doubt but that Mr. RANYARD has succeeded in his most difficult task, and that this publication will forward the solution of the most important questions involved, in a very marked way. The work comes at exactly the right time, and satisfactorily fills its place.

A very elaborate paper on the polarization of the corona, by Dr. SCHUSTER, is published in the M. N. for December, 1879. This paper shows how combined measures of the polarization at different distances from the Sun, and of the decrease in intensity of the total light of the corona with increasing distance from the Sun, may inform us in what way the scattering matter is distributed in the solar atmosphere, what part of the light sent out by the corona is due to scattering matter, and whether the latter is projected outwards from, or is falling into the Sun from outside.

Mr. LEONARD WALDO has published a report on the observations of the solar eclipse of July, 1878, made at Fort Worth, Texas, by a party of which he was the leading member.* An attempt was made to obtain photographic evidence of the polarization of the corona by inserting a double-image prism between the lenses of a camera. The photographs obtained in this way were examined by Prof. PICKERING, who found inequalities in them, which, as far as they go, tend to indicate tangential polarization; but in the opinion of Dr. HASTINGS the evidence is not conclusive. The inner corona was seen by Mr. SEAGRAVE about 30^s before totality. Mr. PULSIFER, using a ten-prism spectroscope attached to a four-inch CLARK refractor, and keeping the slit tangential, observed the reversal of the Frauenhofer lines at the commencement of totality. From the length of these lines, which only reached one-third across the spectrum, the tangential thickness of the reversing layer was found, and from this Mr. PULSIFER infers its minimum height above the photosphere to be 524 miles. The C line was not shortened like the others, but extended right across the spectrum.

The Naval Observatory at Washington, has published the reports relating to the total solar eclipses of 1878 and 1880 in a large 4° volume of 416 pp., accompanied by 25 wood cuts of drawings made by observers and 30 chromolithographed plates. This important volume has been edited by Prof. HARKNESS, who has provided a complete index of persons (4 pages) and index of subjects (6 pages), besides a table of contents of 9 pages. It is worth while to mention these indexes, because their presence seems to be an indication that men of science are beginning to avail themselves of devices which have long been considered indispensable to even the simplest literary performance, and which in the nature of things are still more necessary to technical and scientific writings. This special work, however, deserves a careful review for many reasons, principally in that it is decidedly the most important contribution which has ever been made to the literature of any single eclipse, not excepting the memoirs of DE LA RUE, of LAMONT, and the report of the Austrian Commission on the Aden eclipse.

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* Cambridge, Mass. (J Wilson and Son), 1879. 4to.

The solar eclipse of 1878 is noteworthy, since it was visible over a large portion of civilized country, each part of which it was easy to reach by cheap transportation. The Congress of the United States also placed the sum of $8,000 at the disposition of the Naval Observatory, which was expended in providing the necessary instruments and in placing men and instruments in the proper field. The expenses of 27 observers—mostly astronomers at various universities or colleges—were paid, wholly or in part, from this sum. This governmental action is noteworthy in the history of the country, as indicating the means by which alone government aid to science can be afforded under our form of administration, and it would seem that the question of the "endowment of research," which has been agitating Great Britain, has here been quietly solved. The Naval Observatory accounted to the Treasury for the money, and the funds were spent in placing its own parties and those headed by all the eminent astronomers of the country in the field, and under its auspices liberal arrangements with the customs department and the railways were made for the benefit of foreigners.

To come to the most important particulars of the volume before us: It is preceded by the elaborate Instructions to Observers, compiled by Prof. HARKNESS, of which it may be said that it is the most complete, and on the whole the most satisfactory, which we have. Guided by these instructions, the amateur observers prepared their sketches of the corona and made their observations.

In previous eclipses the principal point to be noted in regard to such sketches has been that each sketch differed so much from every other that only a knowledge of the circumstances under which they were made could allow one to believe that they were representations of the same phenomenon. Here, however, so many sketches were made, each one readily comparable with the photographs made by the parties of Professors HALL, HARKNESS, and HOLDEN, that for the first time a kind of order can be evolved from what has previously been but chaos. The photographs serve always as a standard, and it is seen that each sketch represents (and exaggerates) one or more special features, the other features remaining unnoted. Thus, by combining the whole set a very fair general representation can be had. This is one most important lesson. The photographs themselves are of the highest excellence. The parties of Prof. HALL and of Prof. HARKNESS were provided with complete outfits, and each secured a series of photographs of exposures varying from 3 to 60 seconds. The pictures with the shortest exposures give the details of the corona near the Sun; those of longer exposures giving details further out. In these latter pictures the inner corona is much over-exposed, and its details are thus lost; but by a combination of the set the whole can be built up out to the distance of 20′ from the Sun's edge.

A single photograph was taken by Prof. HOLDEN'S party, which admirably supplements the others, as it begins where the others leave off and carries the picture of the corona out to 60′ from the Sun's limb. Thus the pictures made by the Naval Observatory parties cover the whole ground, and are far more complete than those of any previous eclipse. They are not adequately discussed, however, in the volume before us, which is the less excusable as Mr. RANYARD in his recent work on Solar Eclipses has given a practical example of how such work should be done.

Some idea of the fullness with which these collected reports treat nearly everything which can be made the subject of *observation* may be had by a glance at the subject-index. For example, the contacts were observed at over twenty stations by more than twenty-five observers. Descriptions of the corona are given on thirty-nine different pages, and these do not include the thirty or more drawings. Nearly every one of the phenomena is attested by more than one observer of the many engaged. Thus the corona was seen before or after totality at six stations. Ten persons swept in the vicinity of the Sun for the discovery of Vulcan. Prof. WATSON reports the discovery of two planets, Mr. SWIFT that of two different ones, making four in all, seen or suspected. The report shows that four persons swept over the place of WATSON'S (*a*) without seeing any planet there, and four also swept over the place of SWIFT'S two, also without seeing them. In all these cases the telescopes were of adequate power to have shown the objects of WATSON and SWIFT.

The main results of the eclipse of 1878 may be summed up much as follows:

The connection between the activity of the Sun's surface, as evinced by the number and size of the spots and protuberances, and the nature of the corona, has been again shown. The corona in 1878 was far simpler in general character than those of 1869 and 1870. It was observed to extend to a much greater distance from the Sun in this eclipse than in any other, but this is probably due to specially advantageous circumstances. Professors NEWCOMB and LANGLEY both observed the corona with the naked eye, extending 5° or 6° from the Sun's center. There is much difference of opinion as to the brightness of this corona; it probably was not materially fainter than that of 1869. Photometric observations were made at Pike's Peak upon this point, but there are no earlier observations easily comparable. The most important point of difference between the coronas of 1869 and 1878 was in their spectra. The bright lines due to the gaseous parts were conspicuous in 1869, while in 1878 they were so faint as only to be seen by a few observers, though these lines were undoubtedly present. A continuous spectrum was seen by most spectroscopic observers. The 1474 line was seen at the beginning and end of the eclipse, but only a few observers saw it during the whole of totality. Prof. EASTMAN traced this line all round the Sun, finding it equally bright at equal distances from the center, and what is remarkable, finding no defect in the brightness of this line in the points where absolutely no corona was visible to the naked eye or to photographs. No new bright lines were visible in the coronal spectrum. A new line (K. 534) in the chromosphere was discovered by Prof. **Rockwood**, who, as well as Prof. **Young**, saw both lines brightly reversed. Prof. **Barker** and others saw the Frauenhofer lines (dark) in the coronal spectrum; they were very faint. The polarization of the corona was observed by several parties. The photographic observations of Professors **Harkness** and **Wright** show it to be radial in direction. Prof. **Hasting's** eye observations give tangential polarization. Such are the main facts of observation to be derived from the volume in question. It is yet too soon to state the bearing of these facts upon existing theories or to deduce any general conclusions from them.

COMETS.

The following comets were visible in 1879:

A. **Brorsen's** periodic comet was first seen by **Tempel** on January 14, and on February 26 by **Tebbutt**. It passed the perihelion on March 30, and was observed till the end of May. It was found more than a month earlier than Dr. **Schulze's** ephemeris commenced.

B. **Tempel's** periodic comet was first seen by him on April 24, and was observed until the end of June. It passed the perihelion on May 7, according to Mr. **Raoul Gautier's** elements.

C. **Swift** found a pretty bright comet on June 16, which was independently discovered by **Winnecke** on June 21. It was observed till August 23.

D. **Palisa** discovered a pretty bright comet on August 21, which was seen as late as October 12 (the date of the perihelion passage).

E. Another comet was first seen by **Hartwig** on August 24. The last observation seems to be from September 14.

The spectrum of **Brorsen's** comet appeared this year very different from what it was in 1868. It consisted of three bands, the central one the brightest, and the least refrangible one exceedingly faint. The wave-lengths as determined by **Young**, were 468 ± 2, 517 ± 1, and 558 ± 3. The abnormal character of the spectrum in 1868 (which only one other comet, that of **Borelly**, c. 1877, has exhibited), has therefore disappeared, and the comet has now the ordinary spectrum.*

The following comets were visible in 1880:

Comet A, 1880, was first seen, probably, at the Cape of Good Hope, February 1. It has been usually spoken of as the Great Southern Comet. Dr. B. A. **Gould**, of Cordoba, Argentine Republic, says: "It was brightest February 7 or 8, when its length was 40° and its breadth 1½°, but its brightness not superior to that of the Milky Way in *Taurus*." Another observer says: "The portion of the tail visible was about 34° in length and 2° in width, its long, straight, narrow form resembling the one of 1843, which I remember well, although it was inferior in length and brilliancy to that famous comet." February 4 the head of the comet was 3 minutes of arc in diameter, as reported by Dr. Gould, who also computed the elements of its orbit and found them to agree well with those computed by Hind. The elements of the orbit of this comet agreed very closely with the one of 1843. They are compared below:

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* Young, N. xix. 559, Obs. III. 56, Christie N. xx. 5.

	Hind, 1880.
Per. pass	January 27, 6,027, G. M. T.
Long. per	279 deg. 6 min. 8 sec.
Long. node	4 deg. 1 min. 9 sec.
Inclination	35 deg. 39 min. 8 sec.
Per. dist	0.0059390.
Motion	Retrograde.

	Comet 1843.
Per. pass	February 27.
Long. per	278 deg. 35 min. 1 sec.
Long. node	1 deg. 20 min. 6 sec.
Inclination	35 deg. 39 min. 2 sec.
Per. dist	0.005511.
Motion	Retrograde.

Mr. Hind, in communicating these results to the Astronomer Royal of England, says: "Can it be possible that there is such a comet in the system almost grazing the Sun's surface, in perihelion, and revolving in less than thirty-seven years? I confess I feel a difficulty in admitting it, notwithstanding the above extraordinary resemblance of orbits." The appearance of this great comet has again revived the discussions of a resisting medium in space. Prof. Oppolzer, of Vienna, has published recently two important papers on this theme. Th. Bredichin, of Moscow Observatory, Russia, has computed the numerical value of the repulsive force necessary to produce the enormous tail of this comet, and finds it to belong to the same type of those of 1680, 1744, 1769. I am not aware that any observations by the spectroscope were had during the late appearance of this comet.

Comet B was discovered by J. M. Schaeberle, assistant at the Ann Arbor Observatory, April 6, and its train was easily seen, and was three minutes in length. On the 16th it was brighter and larger. Elements of its orbit were computed by Safford, Holetschek, Bigourdan.

Martin's elements of this comet are in close agreement with the above.

Comet C is Faye's short-period comet. It was seen by Mr. Common, of England, August 2. It was then extremely faint. The periodic time of this comet is 7.413. It was found by the aid of an ephemeris previously computed.

Comet D was discovered by Dr. Hartwig, at Strassburg, September 29, and also independently announced by Prof. Harrington, of Ann Arbor, September 30. It was a bright comet, just visible to the naked eye. "Prof. WINNECKE finds that this comet may be identical with the comet of 1382, 1444, and 1569, as well as that of 1506, and he is led to suggest a period of sixty-two and one-third years as probable."

The spectrum of this comet was observed by KONKOLY, BACKHOUSE, and YOUNG. It gives four bright lines, whose wave-lengths are, respectively, 5,609, 5,492, 5,169, and 4,859 tenth-meters. The spectrum, though faint, was continuous.

October 7, 11, and 12, the spectrum was examined at Greenwich, and was found to consist of the three usual cometary bands, the brightest comparing well with that of alcohol vapor and that of the Bunsen-burner flame.

Comet E was discovered by LEWIS SWIFT, of Warner Observatory, Rochester, N. Y., October 10. It reached its maximum brightness November 16; presented an ill-defined disk several minutes in diameter. The particular feature of interest attending this telescopic comet is that it is identical with comet III of 1869.

Prof. FRISBY, of the United States Naval Observatory, has also computed the elements of this comet from observations by the Washington transit circle. The perihelion distance of the comet appears to be a little greater than that of the earth, and its aphelion is just beyond Jupiter's orbit. These planets may greatly disturb its path in the future. Prof. FRISBY makes its period about five and one-half years.

Comet F was a small bright telescopic object, one minute in diameter, with a distinct central condensation. It was discovered by Dr. PECHULE at Copenhagen; elements were computed by Dr. J. HOLETSCHEK.

Prof. YOUNG observed this comet December 18, 19, and 22, and saw two faint tails. One direct, as usual, away from the Sun, in nearly the opposite direction, and the other roughly toward the Sun, though deflected some degrees to the north. The two streamers made an angle of 150° with each other. "Each was about thirty minutes long on the 18th, and neither was seen after the 22d."

The three periodic comets whose orbits have been the most carefully examined are ENCKE'S, WINNECKE'S, and FAYE'S. Their least distances from the Sun are $\frac{34}{100}$, $\frac{78}{100}$, $\frac{168}{100}$, of the Earth's distance, respectively. It is well known that ENCKE'S original researches indicated the existence of a resisting medium in space which, by opposing the motion of the comet through it, gradually shortened its period of revolution. All of ENCKE'S computations were repeated by Dr. VON ASTEN, and his general results confirmed. Dr. MÖLLER, of Lund, executed a like work for FAYE'S comet, and found no such change in its period and the conclusion was that, granting the existence of a resisting medium, it did not extend so far as one and a half times the earth's mean distance. Dr. OPPOLZER has just concluded a similar investigation for WINNECKE'S comet. He finds that its motion is altered in the same way as that of ENCKE'S comet, and the value of the resisting force is found to be almost the same as that found by Encke. Dr. Oppolzer goes further and shows that, granting the existence of such a resisting force, its effect upon the motion of Faye's comet would be so small as to be confounded with uncertainties of the computed perturbations. The question of the existence of a resisting medium will be definitively settled by computations now in progress upon the other comets of short period.

THE PLANETS.

Vulcan (?).—A new attempt to find an orbit in accordance with the more or less doubtful observations of dark round spots passing across the Sun's disk was published in the A. N. by Herr v. Oppolzer. He found a system of elements which was in remarkably good accordance with the eight observations on which the calculations were founded. Watson's observation during the eclipse in 1878 was not among these, and the resulting orbit made "Vulcan" at that moment be 7° preceding the Sun. A nearly central transit ought to have taken place on March 18, 1879, but nothing was seen, though many telescopes were directed to the Sun that day.

In No. 2253–54 of the A. N. Dr. C. H. F. Peters has published a long article entitled "Some critical remarks on so-called intra-Mercurial Planet Observations." In the first part of this article the writer considers at length the observations made during the eclipse of July 29, 1878, by Watson and Swift, of two unknown objects southwest of the Sun. The fact that the line between the two stars, called *a* and *b* by Prof. Watson, is almost parallel and equal in length to the line between θ and ζ Cancri, joined to the small size of the improvised circles of the instrument, appears to him to prove beyond doubt that the objects seen were nothing but the stars θ and ζ Cancri. The constant error of about 3^m, which, under this supposition, would affect the R. A.s of *a* and *b*, he explains by the different circumstances under which the circle markings were made for the stars and for the Sun; in the former case, in semi-darkness and in a hurry; in the latter case, in full daylight and with leisure. Possibly, also, the markings were made at the same side of the wire-pointer, thus creating a parallax of $\frac{3}{4}^\circ$ or $\frac{1}{30}$ of an inch. Mr. Swift's observation is treated more summarily by Prof. Peters, who thinks the confusion and successive gradations in his statements must deprive every reader of confidence in them.

To this criticism Prof. Watson has given an indignant reply in No. 2263 of the same journal. He denies flatly that his wire-pointers were as easily bent as supposed by Prof. Peters, and feels confident that the probable error of 5′, assigned by himself, is rather too large than the reverse; the 20′ of Prof. Peters he considers perfectly absurd. There is only one of Prof. Peters's objections which he did not answer; he did not state whether he saw *a* and θ Cancri at the same time or not in this paper. This seems to be the crucial point of the whole question, and Prof. Watson, in his report to the Naval Observatory, has distinctly stated this. Mr. **Swift** has also replied in the A. N. 2277. He had, immediately after the eclipse, informed the other observers near him that he had seen two objects with sensible (though, he acknowledged, spurious) disks about 3° S. W. of the Sun, 12′ apart. Later on he changed this estimate to 7′ or 8′ in a letter to *Nature* (xviii, p. 539), in which he made a curious mistake, putting $8' = 2^m$. Prof. **Peters** can hardly be blamed for having felt suspicious at all this confusion, or for having made little of Mr. **Swift's** comparison of the distance between Mizar and Alcor, with the distance between the two unknown objects.

Venus and Mars.—Dr. **Hartwig** has published an extremely important investigation of the diameters of *Venus* and *Mars* from heliometer measures by himself. He has also thoroughly discussed previous observations, and the following instructive table gives the main results:

A.—HELIOMETER.

		i.	Prob. Error.	Aperture.
		″	″	mm.
1820	Brandes	—1·096	±0.134	76
1847–49	Wichmann	—0·436	—	158
1857	Winnecke	—1·088	—	162
1861–63	Main	—1·182	·091	190
1876–77	Hartwig	—1·233	·057	76

B.—DOUBLE IMAGE MICROMETER (AIRY).

		i.	Prob. Error.	Aperture.
		″	″	mm.
1862–65	Kaiser	—0·772	±0·042	189
1840–52	Main	—0·50?	—	170
1873	J. Plummer	—0·546?	—	152

C.—ROCHON'S MICROMETER.

		i.	Prob. Error.	Aperture.
		″	″	mm.
1810–15	Arago	—1·519	±0·105	162

D.—WIRE MICROMETER.

		i.	Prob. Error.	Aperture.
		″	″	mm.
1833–36	Mädler	+0·651	±0·073	97
1854–57	J. Schmidt	+0·116 +0·776	0·245 0·511	108*
1860–64	Mädler	—0·254	—	244
1838–39	Galle	—0·86	—	244
1871	Vogel	—2·56	—	293·5

The negative sign of the constant error for all double image observations is very remarkable, and it appears that telescopes of all apertures make the diameter as measured in daylight too small, while there does not seem to be any law depending on the aperture.

The adopted value is a mean of the Oxford, Leiden, and Strassburg values, 17″.552, which is 0″.60 and 0″.65 greater than the results of observations of *Venus* in transit, by **Auwers** and **Tennant**, in 1874. The obscured hemisphere of Venus was repeatedly seen during the observations.

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* Powers, 120 and 90.

The diameter of *Mars* is deduced (for distance 1) to be polar diameter $= 9''.349 \pm 0''.010$ from the mean of Arago's, Bessel's, Kaiser's, Main's, and Hartwig's observations.

The Strassburg observations alone gave polar diameter $= 9''.311$; equatorial diameter $= 9.519$.

Many good drawings of *Mars* were made in 1877, among which those of Mr. Green, at Madeira, of Mr. Dreyer, and of M. Niesten, at Brussels, deserve especial notice. Mr. Green and Mr. Burton have also observed Mars in 1879.

Neither Mr. Green nor any one else in 1877 succeeded in seeing the remarkable long and narrow canals depicted in Schiaparelli's "Osservazioni astronomiche e fisiche sull'asse di rotatione e sulla topografia del pianeta Marte," Roma, 1878, 4to;* but M. Terby has pointed out that drawings made by Prof. Holden, at Washington, in 1875, contain these canals, and that thus their subsequent discovery by M. Schiaparelli in 1877 is fully verified. This paper, published towards the end of 1878, contains first a new determination of the direction of the axis of rotation, the measures being made by placing the micrometer wire tangent to the middle of the snow spot. The results were, for September 27·0.

$$\left.\begin{array}{l}\text{Areocentr. Long.}\\ \text{“ \quad Polar Dist.}\end{array}\right\}\begin{array}{ll}\text{of centre} & 29^{\circ}\!\cdot\!466 \pm 1^{\circ}\!\cdot\!077.\\ \text{of spot,} & 6\cdot147 \pm 0\cdot123.\end{array}$$

Geocentr. Angle of Pos. of Axis, 164·90±0.10.

The second chapter contains the determination of the areographic position of sixty-two principal points on the surface. From this an exact map on Mercator's projection has been constructed, but as only two colors are used, blue and white, to represent dark and bright, and no shading at all is given, it is rather difficult to compare this map with others. The innumerable "canals," which in all directions cross the map, increase this difficulty. Four representations of the disk in orthographic projection (Table V), founded on all the drawings made at Milan, are very much more adapted to be compared with other maps.

One of the most important publications of the year is the eleventh volume (Part I) of the "Annals of the Observatory of Harvard College," containing Professor Pickering's Photometric Observations made with the 15-inch refractor. The author first made experiments with a Zöllner's photometer and other instruments in which the star is compared with an artificial light, but on account of the want of similarity between the real and the artificial star, and the difficulty of applying a correction for changes in opacity of the air, which only affect the real star, the use of a lamp was abandoned, and all comparisons were made with some bright star in the vicinity of the object observed. All variations in the condition of the air were thus eliminated, both objects being equally affected by it. To insure a comparison free from personal equation or variations due to the observer, it is very desirable that the objects shall resemble each other as much as possible. This result is secured by bringing the images to be compared close together, so that they are both viewed with the same aperture and magnifying power, and the light of both is equally distorted by passing through the same lenses and prisms. A detailed description is given of the many photometers employed.*

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* Of this remarkable work a German translation is about to appear. M. O. Struve has given a very full account of it in the Vierteljahrsschrift der Astronomischen Gesellschaft, XIV, p. 22–39 (1879).

These photometers could only be used for comparing objects very near together, such as double stars or satellites. For somewhat greater intervals two achromatic prisms of small angle were placed in front of a telescope, covering the central part of the object-glass. Two images of any object would thus be formed, separated by an interval dependent on the angle of the prisms, and on their relative positions.

All the photometers described are open to the objection that the loss of light is very great, from 60 to 80 per cent. This was especially felt during the observations of the satellites of Mars, and led to the invention of another class of photometers. The image of some bright star, assumed as standard, passes outside the telescope, and is reflected into the field, after having been reduced by some known amount, until it equals the faint object to be measured.

The instruments having been described at length in Chapter I, the second chapter contains the journal of the observations, while the discussions are given in Chapters III and IV. Conjunctions of planets, already alluded to above, afforded a good opportunity for comparing their relative brightness. The results are:

$$\frac{\text{Albedo of Saturn}}{\text{Albedo of Mars}} = 4.62 \pm 0.07 \qquad \frac{\text{Albedo of Jupiter}}{\text{Albedo of Venus}} = 0.86 \pm 0.02.$$

A series of photometric measures of all the more conspicuous double stars is discussed in Chapter IV.

Part II of vol. XI of the Annals of Harvard College Observatory contains the determinations of the brightness of various satellites. In these researches Prof. PICKERING had great difficulties to overcome on account of the extreme faintness of some of the objects whose light was to be measured; the results, however, are of special interest, as affording some idea of the real size of these minute members of the solar system. Prof. PICKERING'S attention was first directed to the newly discovered satellites of Mars, and he devised various new forms of photometer for the examination of these faint objects. These photometers are all described in Part I, and the first two chapters of Part II (Chaps. V and VI) are devoted to determinations of their constants, by various methods. The problem was one of great difficulty, involving the measurement of a photometric interval as great as that between the Sun and the Moon, the planet Mars being several hundred thousand times as bright as his satellites. As a direct comparison was impossible, the light of the satellite was compared with that received from a small por-

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*An abstract of this description is given in *Nature*, XXI, p 23.

tion of Mars through a small hole 1-100th of a millimeter in diameter, *i. e.*, 1-100th of the diameter of Mars, or about 40 miles, the diameter of Mars in the telescope being one millimeter. Much difficulty was experienced in making such a hole, and it was only after various attempts that Prof. PICKERING succeeded in boring suitable holes in a piece of platinum foil gummed on a glass plate.

The light of Mars seen through the smallest hole that could be made was, after all, much greater than that of the satellite, which must therefore, if its albedo or reflecting power is about the same as that of Mars, have a diameter much less than 40 miles.

The following are the results of comparison with Mars, as well as with Saturn and certain faint stars near which the satellites passed:

Mars=667,000×Phobos in 1877;	equiv. diam.=5.57 miles.
Mars=879,000×Deimos in 1877;	equiv. diam.=4.9+0.1 miles.
Mars=550,000×Deimos in 1879;	equiv. diam.=6.1±0.1 miles.
Mars=461,000×Deimos foll. Mars;	equiv. diam.=6.7 miles.
Mars=673,000×Deimos prec. Mars;	equiv. diam.=5.5 miles.

The equivalent diameter of the satellite is calculated on the assumption that its albedo is the same as that of Mars.

It appears, then, from Prof. PICKERING'S results that Deimos was apparently much brighter in 1879 than in 1877, and that it was brighter by nearly half a magnitude on the following side than on the preceding side of its orbit. In support of this Prof. PICKERING points out that there is a large preponderance of micrometer observations of Deimos on the following side, showing that the satellite was more easily seen in that part of its orbit. The micrometer measures of Phobos were nearly equally distributed. No photometric measures were made of this satellite in 1879. The general result of all the observations is that Deimos is about 14.5 magnitudes (on the photometric scale) fainter than Mars, and about 0.3 magnitude fainter than Phobos, the equivalent diameters of the two satellites being about 7 and 6 miles respectively, corresponding to 0″.010 and 0″.009 at mean distance. That is, the satellites are fainter than an area of the surface of Mars having a diameter of 0″.01 at distance unity, or 1-1000th part of the diameter of Mars. Notwithstanding the minuteness of the points of light compared, a difference in color was detected between the outer satellite and Mars, Deimos appearing to be blue, whilst the artificial star formed by Mars was noted as red.

The observations of the satellites of Jupiter in Chapter VIII are of special interest, from the comparison of equivalent diameters (photometrically inferred) and the diameters as actually measured. The following are the results:

Satellite - - - - - - - - -	I.	II.	III.	IV.
Light ratio - - - - - - - - - - -	1786	2032	1271	3597
Equivalent diameter - - - - - - -	0″.873	0″.818	1″.035	0″.615
Measured diameter - - - - - - -	1″.081	0″.910	1″.537	1″.282
Relative albedo - - - - - - - - -	0.652	0.809	0.453	0.230

The first line gives the ratio of the light of Jupiter to that of each of the satellites, the last the albedo relative to Jupiter. To obtain the absolute albedo for each satellite, the relative albedo must be multiplied by the albedo of Jupiter (0.610). The view that the light of the satellites is variable is not confirmed by Prof. PICKERING'S observations.

A large number of photometric measures of the eight satellites of Saturn were made in 1877–8, special attention being devoted to the variations of light of Iapetus, which were found to extend from 40 to 140 (taking the mean brightness as 100). The following formula was found to represent the variations of light:

$$L = 100 - 50 \sin v + 10 \cos 2v,$$

where L is the light of the satellite at any longitude v.

On this formula Prof. PICKERING remarks, "The absence of the term $c \cos v$ shows that if the variation in light is due to unequal brightness of the two hemispheres of Iapetus, one-half of each will always be turned towards Saturn. In other words, it would present to an observer at the north pole of Saturn the appearance of a half moon, the semicircle to the right being about four times as bright as that to the left.

"Some doubt is thrown on the term $e \cos 2v$, since the comparisons with Saturn do not confirm its presence. Since the value of e is positive, it cannot be supposed to indicate that Iapetus is elongated in the direction of Saturn, although a slight elongation of this kind is probably implied in the assumption that the satellite turns once on its axis during each of its revolutions. An elongation sufficient to produce this effect might be caused by the attraction of Saturn, but it would be far too small to be perceptible photometrically. To make $e = +1$, the equatorial diameter of the satellite turned towards Saturn should be exceeded by that at right angles to it in the ratio of 9 to 11; so great a difference does not seem probable. The term $e \cos 2v$ could also be accounted for by two bright or dark spots on the satellite. A dark spot on one side covering less than a hemisphere would also give a variation in light closely resembling that given by that in the formula. The most natural explanation, however, is that the dark and light portions are irregularly distributed on Iapetus, like the land and water on our Earth, and that one hemisphere is, on the whole, much darker than the other. The smaller variations may be assumed to be such that the formula given above represents them closely."

The following are the equivalent diameters of the satellites in miles found by Prof. PICKERING: Mimas 292±9; Encleadus 370±10; Tethys 570±18; Dione 542±17; Rhea 745±27; Titan 1406±52; Hyperion 193±5; Iapetus, mean 486±4, max. 574, min. 307.

The satellites of Uranus and Neptune have the following equivalent diameters (in miles): Titania 586±16; Oberon 544±15; satellite of Neptune 2260±60. The large equivalent diameter of the satellite of Neptune is noteworthy.

Determinations are also given of the equivalent diameters of some of the minor planets, as follows: Pallas 167 miles; Juno 94±4; Vesta 319±10; Antiope 51±3; Brunhild 20±3; Eva 14±1; Menippe 12±1.

Though these equivalent diameters must not be accepted as actual diameters, they doubtless give a pretty close approximation to the size of the smaller members of the solar system, even allowing for a large uncertainty in the albedo. It would seem from the Harvard College determinations that some of the smaller asteroids are at any rate comparable in size with the satellites of Mars, and the step from these to the larger meteorites is not a very large one. The volume also contains photometric measures of 103 unequal double stars and some miscellaneous results. Great care has been taken throughout to avoid systematic errors by varying the methods of observation, but it is certain that some of the measures of the light of faint companions to bright stars are in error, as shown by comparison of pairs of the same assigned brightness.

A work of some magnitude has been undertaken by Prof. PICKERING during the past year in the determination of the light of all the stars visible to the naked eye at Cambridge (Mass.) As most of these stars would be very troublesome to identify in the field of a photometer mounted on an ordinary stand, they are observed in the meridian. The photometer consists of a horizontal telescope pointing to the west, and having two objectives. By means of two prisms mounted in front of the telescope the pole star is reflected into one object-glass, and the star to be measured into the other. The cones of light are made to coincide by a double-image prism, the extra images being cut off by an eye-stop. The star to be measured is thus seen in the same field with the pole star, under exactly the same conditions. To determine the relative transparency of the air at different altitudes, a list of a hundred circumpolar stars has been prepared, to be observed at both upper and lower culminations. Progressive changes in the light of the pole star may thus also be detected and eliminated.

A Persian MS. of ULUGH BEG'S catalogue of stars recently presented to the Royal Astronomical Society has been examined by Mr. KNOBEL (M. N. xxx, 337), and compared with HYDE'S translation. A great many discrepancies have (as was also the case with SÛFI) been found to arise from certain characters being mistaken for others by the transcriber, and Mr. KNOBEL was hereby led to examine those of IBN JUNIS'S lunar eclipses, which Prof. NEWCOMB had found to be irreconcilable with the computations, and he suggests explanations, founded on the assumption of similar errors having been made in copying a MS. The magnitudes of ULUGH BEG never having been properly translated, Mr. KNOBEL gives a complete translation of the magnitudes as found in the MS. under examination.

Jupiter.—Dr. SCHMIDT has made a new determination of the time of rotation of Jupiter upon its axis, from observations in 1879 and 1880, of the red spot upon its disk. His preliminary discussion gives for the time of rotation 9h. 55m. 34.42s.

On the evening of February 2, Jupiter was passing near the star B. A. C. 303 (73 Piscium), and the opportunity was taken at the observatory of Harvard College to compare photometrically the third satellite of the planet, with the star. Three observers took part in the work, and four sets of measurements, each consisting of eight single comparisons, were made. The result obtained was that the star was fainter than the satellite by 0.38 magnitudes of POGSON's logarithmic scale. For the magnitude of the star we have 6.16 by the mean of the available estimates on record, and 6.17 by the observations made at this observatory with the meridian photometer. The resulting magnitude of the satellite is 5.28 or 5.29, in close agreement with the value, 5.24, found by a very different method, in the Annals of the Observatory, Vol. XI, p. 276.

Saturn.—A letter from Prof. HASTINGS, of the Johns Hopkins University, puts an important point in regard to the nature of *Saturn's* rings (C, the dusky ring, B, the inner bright ring, A, the outer ring) so briefly that it may be quoted. "The ring C projected on *Saturn* is dark; if the ring were composed of particles having the same *albedo* as the planet it would appear neither bright nor dark, as it would return to us by reflection the exact equivalent of what it intercepts. But the *albedo* of B is greater than that of the planet since it is the brightest part of the system. Hence either the material of C is different from that of B, or the planet is self-luminous."

Possible planets beyond Neptune.—Prof. FORBES, of Edinburg, and Mr. D. P. TODD, of Washington, have, during the year, published accounts of their theoretical proofs of the existence of a planet or planets beyond *Neptune.* Prof. FORBES founds his conclusions upon the statistical distribution of the aphelia of comets. These have long been known to be grouped at certain distances from the sun, with empty spaces so far as known between groups. There is a group of eleven comets whose aphelia are at Jupiter's mean distance, 5, and another group of six comets about Neptune's distance, 30.

Another well marked group of seven comets have aphelion distances of about 100.

The theory of the introdution of comets into the solar system, proposed a few years since by Prof. Newton, of Yale College, is made the basis of the investigation, and according to this, any comet which is drawn into our system from outside and its elements so changed as to make it a permanent member of the system must have been so influenced by a planet which was somewhere near the aphelion point of this comet's orbit at the time of its introdution.

If the aphelion points of the seven comets of the last group described be marked on a globe, it is found that they lie on or near a great circle. Prof. FORBES further finds that a planet revolving at a distance 100 in a periodic time of 1,000 years might have been at the points so marked during the period of two revolutions of the comets of this group, and from this and other reasons it is concluded that there *is* such a planet revolving at the distance of about 100, which is at present in R. A. 11^h 40^m N. P. D. 87°.

Similar considerations are applied to the next group of comets of aphelion distances about 300, and evidence of a disturbing planet at this distance also is adduced. Prof. FORBES has applied the method he has used to the case of the comets which we know to revolve near Neptune, and, without any knowledge of Neptune's real position, he found that the aphelion positions of these comets indicated the existence of a planet in longitude 45°. In fact, Neptune is now in longitude 48°. From all of which Prof. FORBES concludes the existence of at least one ultra-Neptunian planet in the position indicated, *i. e.*, for 1880, R. A. 11^h 40^m N. P. D. 87°.

The publication of Prof. FORBES'S results has caused Mr. TODD, of Washington, to print the results of some investigations he has made in the motions of Uranus and Neptune as compared with Newcomb's tables of these planets. Proceeding by a graphical method he was led to the conclusion that there must be a planet exterior to Neptune revolving in an orbit inclined about 1½°, whose ascending node is at longitude 103°, and whose longitude is about 173°, or, for 1881, March, its position is R. A. 11^h 37^m N. P. D. 87°.

In other words, Prof. FORBES and Mr. TODD, proceeding on utterly different data, have arrived at identically the same result. In each case the data are insufficient and the exact agreement is accidental. Still it is noteworthy.

It is extremely doubtful if such a planet would be recognizable by its disk at this distance from the sun. Still, Mr. TODD made a search for it with the 26-inch telescope at Washington, without success however. The true method of research would be the accurate mapping of this portion of the sky—a work of several years.

Minor Planets.—The following discoveries were made in 1879:

Date.	No.	Name.	Discoverer.
1879.			
February 17	192	Nausika	Palisa.
February 28	193	Ambrosia	Coggia.
March 22	194	Proene	Peters.
April 28	195	Eurycleia	Palisa.
May 17	196	Philomela	Peters.
May 21	197	Arete	Palisa.
June 13	198	Ampella	Borrelly.
July 9	199	Byblis	Peters.
July 27	200	Dynamene	Peters.
August 7	201	Penelope	Palisa.
September 23	202	Chryseis	Peters.
September 27	203	Pompeia	Peters.
October 8	204	Calisto	Palisa.
October 13	205		Palisa.
October 15	206	Hersilia	Peters.
October 17	207		Palisa.
October 21	208		Palisa.
October 22	209	Dido	Peters.
November 12	210		Palisa.
December 10	211		Palisa.

Frigga (77) was refound by **Peters** on July 17, 1879, after having been at large for several years. Prof. **Peters** suggests that Frigga may be variable.

The discoveries for 1880 were:

Date.	No.	Name.	Discoverer.
1880.			
February 6	212		Palisa.
February 17	213	Lilaea	Peters.*
March 1	214		Palisa.
April 7	215	Oenone	Knorre.
April 10	216		Palisa.
August 30	217		Coggia.
September 4	218		Palisa.
September 30	219		Palisa.†

* His 41st discovery. † His 28th discovery.

The *Jahrbuch* for 1882 gives some details regarding the first 173 asteroids, which we condense as follows: Out of these 173, there are 120 which have been satisfactorily observed at 5 (or more) oppositions, 11 which have been observed at 4 oppositions, 10 at 3, 14 at 2, and 18 at 1 only. Of these last 18, some are new discoveries and only *Dike* (**Borelly**), and *Scylla* (**Palisa**) are yet to be rediscovered. *Juewa* (**Watson**) has been lately found, after having been lost six years.

The Moon.—The lunar photographs taken with the 13-inch reflector at the University Observatory, Oxford, have been utilized for finding a new value for the semi-diameter of the Moon. The process adopted was very nearly the same as that employed by **Wichman**, and the resulting mean semi-diameter is $15' \, 34''.175 + 0''.069$. Mr. **Neison** has, from a careful discussion of nearly 1,100 observations, made at Greenwich, Oxford (**Radcliffe**), and Washington, deduced the value—

$$15' \, 33''.37 + 4''.10 \div (1 + 0''.70 \times \text{aperture in inches}).$$

This empirical formula, he adds, agrees closely with the theoretical formula, founded on the assumption that the differences between the semi-diameters obtained with instruments of different aperture vary as the diffraction discs and the amount of light. Applying the formula to a 13-inch reflector, and adding the photographic irradiation, which Mr. **Nieson** states his experiments indicate to be about $+ 0''.3$, the photographic semi-diameter should be $15' \, 34''.08$.

No papers on the Moon published during the past year exceed in importance those by Mr. G. H. **Darwin** on the secular effects of tidal friction on the configuration of a planet and its satellite. In the first paper the theory of the deformation of a viscous or imperfectly elastic spheroid under the attraction of satellites is investigated. Numerical calculations show that bodily tides in the Earth are at present very small. From this point Mr. **Darwin** was led to consider the perturbed rotation of such a spheroid, and the reaction on the perturbing bodies. He has in the A. N. 2294 given the following summary of the results arrived at through these investigations, which, no doubt, mark the beginning of a new era in our knowledge of the past history of the solar system:

1. The lunar period must have been shorter in the past, and may be traced back from the present 27.3 days, until initially the Moon revolved round the Earth in from two to four hours.

2. The inclination of the orbit to the "proper plane" must have been larger in the past, and may be traced back from the present 5° 9′ until it was 6° or 7°. This was a maximum inclination, and in the more remote past the inclination was less and initially was very small or zero.

3. The inclination of the proper plane to the ecliptic must have been greater in the past, and may be traced back from its present 8″ until it was in very early times about 11° 45′. It is possible that initially this inclination was less, and that the 11° 45′ was a maximum value.

4. The eccentricity of the orbit must have been smaller in the past. Either at one time it had a minimum value, before which it had a maximum value, and, again, earlier it was very small or zero, or else the maximum value never occurred, and the eccentricity has always been increasing. The history of the eccentricity depends on the nature of the tides in the Earth, but the former of these alternatives seems the more probable.

At the present time the Earth rotates in twenty-four hours, its equator is inclined at an angle of 9″ to a plane which Mr. DARWIN calls "the proper plane of the Earth" (the mean equator). This proper plane is inclined at an angle of 23° 28′ to the ecliptic, and its intersection with the ecliptic is the equinoctial line. He finds that the frictional tides in the Earth have caused changes which may be summarized as follows:

5. The day must have been shorter in the past, and it may be traced back from its present value of twenty-four hours until initially it was from two to four hours in length. It was then identical with the Moon's period of revolution as described in (1).

6. The inclination of the equator to the Earth's proper plane must have been larger in the past, and may be traced back from the present value of 9″ until it was about 2° 45′. This was a maximum inclination, and in the more remote past the inclination was less, and initially it was very small or zero.

7. The inclination of the Earth's proper plane to the ecliptic must have been smaller in the past, and may be traced back from its present value of 23° 28′ until initially it was 11° 45′, or, perhaps, somewhat less. It was then identical with the proper plane of the lunar orbit, and this is true whether or not 11° 45′ was a maximum inclination of the lunar proper plane to the ecliptic as described in (1).

The preceding statements may be subject to varieties of detail, according to the nature of the tides raised in the Earth, but the above is a summary of what appears to be the most probable course of evolution.

The hypothesis which is suggested as most probable is, that the more recent changes in the system have been principally due to oceanic tidal friction, and that the more ancient changes were produced by bodily tidal friction. The initial state of the Moon, nearly in contact with the Earth, and always opposite the same face of it, suggests that the Moon was produced by the rupture in consequence of rapid rotation or other causes of a primeval planet, whose mass was made up of the present Moon and Earth. It is a remarkable coincidence, that the shortest period of revolution of a fluid mass of the same mean destiny as the Earth, which is consistent with an ellipsoidal form of equilibrium, is two hours and twenty-four minutes; and that if the Moon were to revolve about the Earth with this periodic time, the surfaces of the two bodies would be almost in contact with one another. The theory gives an interesting explanation of the rapid movement of the inner satellite of Mars.

OBSERVATORIES.

The buildings of the new observatory of the University of Strasburg have been completed, and a description and plates of them made by the director, Dr. **WINNECKE**. The principal instruments are:

1. A meridian circle by **REPSOLD**; aperture 162 millimeters (6.4 inches).
2. An altazimuth by **REPSOLD**; aperture 136 millimeters (5.4 inches).
3. A refractor by **MERZ**; aperture 487 millimeters (20.2 inches).
4. An orbit-sweeper by **REPSOLD**; aperture 163 millimeters (6.4 inches).

There are three buildings—one large one containing the residences of the astronomers, and two smaller.

On the main building is the large iron dome, some 39 feet in diameter. There are two novelties in its construction: First, the shutters to the dome are made in two parts, and extend from horizon to horizon. They are opened symmetrically by screws, and leave the whole 180° open at once. Secondly, the dome, which weighs about 93,000 pounds, is turned by means of heavy weights, which are wound up from time to time as required. A touch from the observer will release these, and their fall will turn the dome right or left as required. The working of this dome will be attentively regarded, as most of the difficulties of such structures appear to have been successfully avoided. In windy situations the whole slit must not be opened at the same time, but the principle of these shutters properly modified will serve even in this case. The dome of the new Naval Observatory at Washington is to be of the turret construction, by which form the difficulties of shutters can be evaded.

The 27-inch refractor for the Vienna observatory has been finished by Mr. **GRUBB**, and is now mounted, and is said to be satisfactory. An elaborate description of it is published by Mr. **GRUBB** as a reprint from *Engineering*.

Mr. A. A. **COMMON** has mounted his new 36-inch silver-on-glass equatorial at Ealing, near London. It is described in "The Observatory," III, p. 167, and Mr. CALVER has given a very full account of the process of figuring and silvering the mirror in the M. N. for November.

A new observatory has been founded at Kalocza in Hungary, by Cardinal Archbishop HAYNALD. Dr. CHARLES BRAUN is the director, and the chief instrument is a 7-inch refractor by MERZ.

Another private observatory has been constructed at Plonsk, about 37 miles from Warsaw, by Dr. JEDRZEJEVICZ. The principal instrument is 6.4 inch refractor by STEINHEIL, to be used for observations of double stars.

The new observatory of Queen's College, Cork, though furnished only with small instruments, promises to become one of the most remarkable astronomical institutes existing, on account of the unique character and refined construction of its instruments. These have been described at some length in the Scientific Proceedings, Royal Dublin Society, by their constructor, Mr. HOWARD GRUBB. The principal instruments are an 8-inch equatorial, a 5-inch transit circle with 20-inch circles of glass, and a 4-inch siderostat of novel construction. The telescope of this instrument points towards the south pole, and carries outside the object-glass a plane silvered mirror, which, by the rotation of the tube round its optical axis (either by hand or clockwork), will keep the object under examination in the center of the field.

An observatory is being built on the site of the "Casa degl' Inglesi," on Mount Etna, 9,650 feet above the sea. It is only to be inhabited during the months of June, July, August, and September; and the 12-inch lens, by MERZ, is then to be brought to Catania, where there is to be a duplicate mounting for it. The observatory is to be devoted to solar work, for which its high elevation, according to the experience of Prof. TACCHINI, as also of Prof. LANGLEY, makes it especially suited.*

M. BISCHOFFSHEIM is building a new observatory at Mont des Mignons, Nice, of which M. PERROTIN, of the Paris Observatory, has been appointed the director. A sum of 900,000 francs is to be spent on it.

It is now more than five years since JAMES LICK, of San Francisco, placed in the hands of trustees the sum of $700,000 for the purpose of erecting and equipping an observatory near the Pacific coast, which was to constitute the Lick Astronomical Department of the University of California.† The site originally chosen was at Lake Tahoe; but afterwards a series of experimental surveys was made, with a view of obtaining the best location in an easily accessible place. Finally, Mount Hamilton, in Santa Clara County, about 50 miles southeast of San Francisco, was chosen, and negotiations were opened with the county authorities for the building of a road to the summit. More than 1,500 acres of land were secured for the observatory, only a small portion of which is essential to the immediate needs of the buildings, but the residue will be utilized for pasture, and for fuel and water-supply. The steep and broken character of the ground renders a large surface of land necessary for the adequate protection of the observatory from fire and intrusion.

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* A plan of the observatory is given in *Nature*, xix, p. 558.

† The following account is borrowed from *The Kansas City Review of Science and Industry*, Vol. III., p. 482. (December, 1879.)

In order to observe the transit of Venus in 1882, the Lick trustees have secured a 12-inch refractor, made by **Alvan Clark & Sons**, who are to make a 36-inch refractor later. A 4-inch transit instrument has been ordered from **Fauth & Co.**, Washington, to be mounted in 1881. A plan for the buildings has been made by Professors **Newcomb** and **Holden**, in which the library, study, computing and sleeping rooms are to be attached to the main building, and the dwelling-houses, etc., will be close by, on a shelf of the hill lower down.

The second volume of **Oppolzer's** "Lehrbuch zur Bahnbestimmung der Kometen und Planeten" has appeared in October last, nearly ten years after the first volume. Such a work was indeed a desideratum. The book enters into the most minute details, and gives examples fully worked out to an extent which neither **Watson's** excellent "Theoretical Astronomy," nor the shorter, though in some parts more comprehensive, "Theoretische Astronomie" by **Klinkerfues**, have attained.

Mr. **Stone** having been appointed to the Radcliffe Observatory, Oxford, Mr. **Gill** succeeded him as Her Majesty's Astronomer at the Cape. Mr. **Gill** purchased Lord **Lindsay's** heliometer, with which he had already done such excellent work himself, and had it mounted on a new stand by Mr. **Grubb**. He intends to apply this instrument to investigations on the parallax of some stars having large proper motions, and to researches on southern star-clusters. Dr. **Elkin**, of New Orleans, goes to the Cape as assistant to Mr. **Gill**.

Prof. **Holden** has been appointed director of the Washburn Observatory at Madison, Wis., in the place of the late Prof. **James C. Watson**.

INSTRUMENTS.

Alvan Clark & Sons, of Cambridgeport, have now on hand, in all the various stages of completion, a most interesting collection of large refractors, to say nothing of a number of glasses of 8 inches or less diameter.

The lenses of the 23-inch equatorial for Prof. **Young**, at Princeton, are receiving the finishing touches, and have already shown a remarkable degree of perfection. The glass was cast by **Feil**. The mounting for this instrument is well advanced.

A 16-inch objective for Prof. **Swift**, of the Warner Observatory, is finished, and the mounting nearly so. This glass is of English manufacture.

The **McCormick** glass of 26 inches aperture, made at the same time as the Washington refractor, and intended for the University of Virginia, is still in the shop and has been completed for several years, while the mounting requires but comparatively little additional work.

Two 8-inch refractors have been ordered and are partially finished—one ordered by Prof. YOUNG for the seminary at South Hadley, and the other by Dr. ENGELMANN, of Leipsic.

The flint glass disk for the 30-inch telescope, ordered by STRUVE for the Russian Government, has been received from FEIL, and the crown glass is expected shortly. The mounting for this will probably be made abroad.

For the Lick trustees a 36-inch refractor is ordered, but it will not be completed for several years. A 12-inch equatorial for observing the transit of Venus is nearly finished, and orders have been received for a 5-inch photoheliograph and a smaller comet-seeker.

In all or nearly all of these instruments the cell of the object-glass is arranged so as to separate the lenses by several inches and allow a free circulation of air between them, as well as to afford an opportunity of readily reaching the inner surfaces of the glass. This device is adopted in the hope of bringing the temperature of the glass as nearly as possible equal to that of the external air, but it remains to be seen if it is really advantageous.

A new 10-inch equatorial, with an object-glass by MERZ, has been presented to the Geneva-Observatory by its director, Prof. EMIL PLANTAMOUR. It is to be devoted to observations of the major planets and their satellites, of parallax of stars, and of double stars, with occasional observations of minor planets.

ASTRONOMICAL BIOGRAPHY, BIBLIOGRAPHY, ETC.

The first number of the new *International Journal of Astronomy—Urania*, edited by Drs. COPELAND and DREYER, contains in a very convenient form of 24 demy 4to pages, a number of interesting articles. Among others, are the following papers: "Observations of the Spectrum of Comet 1880 d. (HARTWIG) at Dun Echt," by COPELAND and LOHSE. "A New Planetary Nebula," by Dr. COPELAND.* "Observations of Comets 1880 b, c, and d, at Dun Echt. "Uber die Auflösung der Lambert'schen Gleichung für Parabolische Bahnen," by Professor KLINKERFUES.

A special reference should be made to the new arrangement given to the tables of the American Ephemeris for 1882 by the superintendent, Prof. NEWCOMB, by which it has become the most convenient of astronomical almanacs. It should have a short Index added to it.

"Obituary Notices of Astronomers" is the title of a little book by Mr. DUNKIN, in which are collected some obituary notices of Fellows and Associates of the R. A. S., mostly written for the annual report in the Monthly Notices, but revised, and some of them partly rewritten.

"Répertoire des constantes de l'Astronomie, par M. J. C. HOUZEAU," occupies 271 pages in 4to of the Annales de l'Observatoire Royal de Bruxelles, Nouvelle Serie, T. I. This is a most wonderfully useful publication, and it is hard to understand how astronomers hitherto have managed to get on without such a handbook; it is only a great pity that it has not been published in the shape of a handbook, but in a place where it will not be easily accessible to many people. It gives in twenty chapters, chronologically arranged, lists of all the different values of astronomical constants, which have been published from the earliest times and down to 1877, in all cases describing the way of finding the particular value and adding exact references, by means of which any one can find out for himself all about any value. And more than that, the titles of the principal books and memoirs relating to any subject within the range of the repertory are also given, but completeness is not aimed at in this respect. The lists of constants are very complete and nearly always correct, and critics of M. HOUZEAU'S work must first show that they could do better that which is extremely well done.

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* This is, however, not a new one, having been discovered by Mr. BURNHAM, in 1873.

M. HOUZEAU, who by this excellent piece of work has shown himself eminently familiar with astronomical literature, ancient and modern, and who already in his "Catalogue des Ouvrages d'Astronomie et de Meteorologie qui se trouvent dans les principales Bibliothèques de la Belgique" (1878), has given a very convenient bibliography, is publishing a "Bibliographie générale de l'Astronomie" in conjunction with M. A. LANCASTER, of the Brussels Observatory. This work is to be divided into three parts, Books, Memoirs, and Observations, and will be a most useful guide in the literature of Astronomy.

An index to the records of observations, etc., outside the ordinary routine work at Greenwich, was printed in the Monthly Notices (xxxix, p. 505).

A complete "Subject-Index to the Publications of the U. S. Naval Observatory from 1845 to 1875," 74 pages 4to, by Prof. E. S. HOLDEN, is published in the Washington Observations for 1876.

A list of books and memoirs on celestial spectrum analysis, by M. FIÉVEZ, appears in the "Annuaire de l'Observatoire de Bruxelles" for 1879, pp. 255–338.

To commemorate the centennial of the discovery of Uranus, we have "Sir WILLIAM HERSCHEL, his Life and Works," by Prof. HOLDEN, of the United States Naval Observatory, Washington.

In 1847 DE MORGAN wrote: "The clear and powerful results of WILLIAM HERSCHEL'S mind lie buried in the *Philosophical Transactions*, inaccessible to the larger portion of those who might learn from them to form a true taste in speculative astronomy, and a true notion of the state of our knowledge of the fabric of the universe."

Thirty years after this was written, and two generations after HERSCHEL'S death, there is still no readier means of studying his works than the original volumes of the *Transactions*, now become rare and costly. And what is perhaps more widely noticeable outside the circle of special students, there is still no biography of the greatest of practical astronomers and one of the most profound philosophers in modern times. The discoveries recited in HERSCHEL'S wonderful series of memoirs have now become part of the common stock of knowledge; even the most casual reader will care to know how they came about.

In seeking to supply for special students the first of these great wants, by A SYNOPSIS OF THE SCIENTIFIC WRITINGS OF HERSCHEL, now publishing by the Smithsonian Institution at Washington, which he has written in connection with Dr. HASTINGS, Prof. HOLDEN has been led to supply the second also, for the more general reader, in the biography above named.

An account of Part II of the *Catalogus Librorum* of the Pulkova observatory must be deferred until the next year, this important work having but just reached this country.

GEOLOGY.

By George W. Hawes, Ph. D.,
Curator in the National Museum.

SURVEYS.

Our National and State governments have never failed to appreciate that the questions to be answered by geological investigation are so numerous, and of importance in so many directions, that public aid should be given such studies in order to render them systematic and more nearly complete. That we remain most ignorant of the structure and geological resources of some of the oldest and ablest States is, however, a fact which will attract attention. The investigations that have been made during the past two years have aided much in developing a knowledge of the natural history and resources of wide areas. The State of Pennsylvania, for example, has, through its geologist, Professor Lesley, published now in all, since 1875, forty-two volumes, seventeen of which appeared during the last year. This may serve as an example of the zeal with which investigation in this department of science has been prosecuted. As the amount of work produced is dependent upon the working force, a statement of some of the more important events that have influenced the public surveys will be given.

Before the past year the surveys patronized by the national government had been prosecuted by parties working independently under the supervision of different executive departments. Although much of the work produced by these various surveys was acknowledged valuable, it was thought by many that if they were consolidated and placed under one head, this would be of weighty importance in causing the work to be more systematically done, and would also prove an economical measure. A committee of the National Academy of Science, to which this matter was referred, reported to Congress that they advised all government surveys to be consolidated under two heads: 1st. A survey of mensuration, by which the work previously done by the coast, and geodetic, and land surveys should in the future be done; and 2d. A survey to which should be referred all questions relating to the geological structure and natural resources of the public domain. This resulted in the organization of the present United States

Geological Survey, and the withdrawal of appropriations from all previously existing surveys. There was much discussion and some feeling excited in the selection of a suitable director for this survey, though the appointment of Clarence King, who is so well and favorably known for his excellent geological work upon the fortieth parallel, produced general satisfaction. He immediately organized a working force for geological investigation in the public domain, and although the new survey has as yet made no reports, the well-known ability of the gentlemen who are at work in this field is an assurance of many and valuable contributions to science. In the mean time the old surveys have been permitted to finish their work, and the result is the addition of several volumes to the geological literature treating of the Western Territories.

Several of the State surveys have issued volumes. The work of the large and active corps engaged upon the Pennsylvania survey has been already noticed. If in speaking of this and other work by surveys I am unable to give any details of their interesting discoveries on account of their number, it is none the less important to draw attention to the volumes from which information can be obtained upon the structure and resources of some of our most important territory from an economic standpoint.

The Wisconsin survey has published a large and valuable volume, which contains work by Irving, Pumpelly, Brooks, Wright, and others, and which gives much information concerning Lake Superior formations and their constituent rocks. The nature and origin of the Lake Superior iron ores and copper ores have always been subjects of much interest. Foster and Whitney early examined and reported upon these deposits, but for many years the testimony of students has been such as to convince that, in opposition to the views of Foster and Whitney, the iron ores are metamorphic strata, and that the copper was introduced into the diabases and sandstones by solutions of copper salts and there reduced to metal and deposited. Mr. M. E. Wadsworth, however, has reopened the question, by having reached the conviction that the iron ores are eruptive rocks, as advocated by Foster and Whitney, and that the copper also was an accompaniment of the eruption of the diabases. Although few are found at present to agree with Foster and Whitney, it is thus seen how difficult it is to establish beyond dispute even the simplest questions of geological structure. The volume on Wisconsin geology treats the iron ores as metamorphic schists, and contains a great deal of careful lithological and stratigraphical work.

It will be remembered that the geological survey of California, which was long directed by Prof. J. D. Whitney, has been discontinued. What the State refused to do has, however, been pushed forward by the private enterprise and energy of Professor Whitney, aided by Harvard College. His volumes upon the auriferous gravels of the Sierra Nevadas is a very valuable contribution to science, since it treats of the gravels from a geological standpoint, and also of the modes of working them. The author still holds fast to his opinion that the celebrated Calaveras skull, which was found by him beneath the lavas and gravel of the Pliocene formation, really was deposited with these gravels, and is confident that he was not deceived. He is confirmed in his opinion by the appearance of the skull and the testimony of others who have examined it. On the other hand Hughes, Dawkins, and others are convinced that all evidences of man's existence on the European continent before the palæolithic age are very unsatisfactory, and the age of the Calaveras skull is a thing which even those who believe in its antiquity will wait to see confirmed.

The Ohio survey has, under the direction of Prof. J. S. Newberry, published a large volume and an atlas; Alabama, New Jersey, Minnesota, Indiana, Virginia, Kansas, and the Canadian geological surveys under direction of their respective heads, have issued volumes and reports which render knowledge concerning the structure and resources of these areas accessible.

There has been a considerable amount of work done in the mean time by individuals. It is to be considered as probable that such work will always take high rank in value, because it is undertaken only on account of deep personal interest, and is more limited in extent, and therefore often more thorough. Much of the work referred to beyond is the result of private enterprise.

STRATIGRAPHY.

The great mass of the communications to geological science from this country have dealt with stratigraphical geology. The volumes of surveys to which I have referred have been shown to be so numerous that I can do no more than to simply indicate that there has been great progress in the development of detailed knowledge of the stratigraphical arrangement all over the country. I may recall in this connection the work of Professor Dana, by which the so-called Taconic system of schists are shown to belong to the Hudson River period. The age of this system of rocks, which is of much importance in Green Mountain geology, has been long a matter of dispute, and has been discussed by very many able geologists, and this is not the first time that Professor Dana has expressed his opinion upon this point. His studies have also led him to think that the limestones of Westchester County and New York Island and the associated metamorphic rocks are of lower Silurian age, as are also the limestones and very likely the associated schists of the Green Mountain region. These conclusions, if they are agreed in, must be of very great importance, for at the present time it is generally considered here and abroad that the presumption is in favor of the Archæan age of a thoroughly crystalline schist. Note, for example, the German nomenclature of the Archæan formation. Its lowest member is the "Urgneiss" formation, and its next member is the "Krystallinische" or the "Urschiefer" formation. The recognition of a whole system of Silurian crystalline rocks would certainly produce a radical change in the existing opinions of many geologists. It is indeed recognized that fossils have been found among crystalline rocks, but since the lowest formations are crystalline, and the lowest of all are gneisses, in the absence of fossils among such rocks they have been called Archæan. This has been much to the convenience of the geologists and much to the benefit of system. Geologists are slow to change their convictions, therefore, on this point, because also some crystalline schists of claimed modern age, as, for example, among the Alps, have been proved to be not so. The unaided work of Professor Dana must be considered as an important contribution to the literature of this subject, as also to New England and New York geology. One can not but be struck by the fact that while the stratigraphy of the fossiliferous formations of New York were worked out in such a masterly manner as to give the nomenclature to American geology, the crystalline formations, both as regards their lithology and their stratigraphy, were left as a completely unsolved riddle.

VOLCANIC PHENOMENA.

The violent eruption of Mount Etna has been the most important volcanic event of the year. This is not because it was so especially grand or remarkable, but Etna and Vesuvius have been longer and more critically studied than any volcanoes on the earth; and consequently every minor event connected with these volcanoes, situated so near centres of scientific learning, is very important, while an eruption of any volcano in distant lands is less interesting only because less studied. When early in May, 1879, it was announced that Etna was in eruption, hours had not elapsed before eminent scientists were en route from all parts of Europe. The lavas were not cold before they were analyzed and microscopically examined; and the number of independent works which have followed one another, treating of the phenomena and products of this eruption, has been so large as to show the acute expectation with which the operations of this great volcano are watched. The material erupted formed very large lava streams, which crystallized into an augite andesite. Professor von Lasaulx, of Kiel, has recently edited the extensive work of Sartorius von Waltershausen on Etna, and has completed it and added numerous observations of his own.

Vesuvius has also had its eruption, and this has strengthened the opinion of some who think that there is some connection between this volcano and Etna. Mauna Loa has also had a grand eruption, and the volcanic glasses of the Hawaiian Islands have been studied by Cohen. But perhaps the most interesting eruption has occurred near us, and has been described by Mr. Goodyear and by a commission sent out by the Government of Guatemala. In December, 1879, an earthquake occurred at San Salvador which filled the earth with cracks, broke the telegraph wires, shook down hills, produced great land slides, and opened a volcanic vent in the midst of a lake, about which a large island immediately proceeded to build itself. The lake is called the Ilopango See, and is nine kilometers long and seven kilometers wide. The level of its waters was raised before the eruption to such a degree as to make a flood in the valley of its outlet; and its waters were so heated and impregnated with sulphureted hydrogen as to exterminate the fish, which were very abundant in the lake. The dead fish were buried with great labor and expense, in order to avoid pestilence. The volcanic cone in the lake repeatedly grew to considerable dimensions, and was as repeatedly blown to pieces. This lake is surrounded by volcanic cones, and reminds one of the well-known Laacher See, which, however, has no outlet. One looks forward to the time when volcanic phenomena near us will receive the critical and continuous study which alone can make them of extreme interest.

Some other European volcanoes beside Vesuvius and Etna have been monographed. The work of F. Fouqué, aided by the French Government, on Santorin and its eruptions, is one of the most beautiful and complete treatises which has been devoted to a volcano. The topography of the island, the history of all the eruptions, records of which exist in history, outlines illustrating the various changes that have taken place in the form and extent of the island, and beautiful pictures of the microscopic sections, illustrating the mineral composition of the various eruptions, all combine to make an interesting and instructive volume. Santorin is a crescent-shaped island in the Grecian Archipelago. It has several craters, part of which are submarine. The last eruption occurred in January, 1866, which materially increased the size of the island. This, together with the other historic and the prehistoric eruptions, are treated in much detail; and the 440 pages of this quarto volume show how greatly science is enriched by careful study of small areas.

LOESS.

The question of the origin of the loess formations has excited much interest. Loess is that very fine-grained calcareous unstratified deposit which occupies the river valleys of many rivers, notably the Rhine. It is characterized by the inclusion of the shells of land snails, and by concretions of limestone, which take very peculiar shape, looking very much like potatoes, but liable to take any form. The Germans call them loess dolls. This deposit is so firm in its texture that when a cut is made through it, its walls will not crumble and wash away, as do the walls of ordinary loose material, but for years they will maintain their vertical surfaces, and preserve marks that are made in them with knives or walking sticks. Indeed, names and pictures carved an these loess walls form one of the characteristic fossils of the formation. Von Richthofen, who knew this formation well, has shown that it, or a like formation, exists over large areas in the Asiatic interior, and he has considered that it is there a wind deposit, and he extends this explanation to the loess in the valleys. Pumpelly, who has also had opportunity to see these deposits in the dry steppes of Asia, has agreed with von Richthofen, but his discussion of the question and the application of the theory to the formation in the Mississippi Valley, incited dissent from Winchell, Hilgard, Broadhead, and Todd, all of whom are familiar with the formation in the Mississippi Valley, and who all agree that no æolian hypothesis will explain the accumulation of this material, and they consider that the facts show that it was gathered in quiet fresh waters, though salt-water shells are not entirely absent. They show that the Mississippi formation is identical with that in the Rhine Valley, and possesses all its strange peculiarities, and that hence this river valley formation was not made of drifting sands anchored by grass, such as accumulates upon the steppes and deserts.

DRIFT.

Another of the great unsettled problems is the origin of the drift that is, there still remain advocates of opposing theories. Credner does not hesitate still to refer the drift that covers our northern lands to the action of floating ice, nor is he alone in his opinion. Mr. Upham, who worked upon the surface geology in New Hampshire, in connection with the geological survey, has traced what he considers the terminal moraine of the great glacier sheet that covered the northern portion of America, almost across the country. He finds this terminal moraine stretching along Long Island, westward across New Jersey, and thus onward. He finds remains as well of a second parallel moraine, farther to the north, which marks a stage in the retreat of the glacier. It is worth remarking that the drift deposits which cover the extensive North German plain have been subjected to much and careful study during this period. The character of the bowlders, which are largely identical with Scandinavian and Finland rocks, have been much studied, and those works which have attracted most attention, notably that of Berendt, do not attempt to explain all facts by referring them all to an unyielding system. Rather, the facts tend to confirm a belief in the alternations of the action of floating ice and glacier, and distinctions between the undoubted action of the one and the other are clearly recognized. By Mr. Upham, as by most recent students, the effects in America have been mostly referred to the action of an immense glacial sheet, with local tributaries, and to the rush of waters attendant upon the melting of this body of ice.

COAL.

Small deposits of coal have been found in various geological horizons lower than the carboniferous. For example, anthracite of silurian age occurs on the Isle of Man, and is supposed to have been formed from an accumulation of algæ. It has been found in the graptolite bearing silurian schists of Scotland, Ireland, Portugal, and also in New York State. But Inostranzeff has shown that a large bed of anthracite, which is worked on a large scale in the Saoneshje region of Russia, belongs to the Huron age. He finds four kinds of carbonaceous mate rial, and among these graphite is found. This carries the coal period back into the archæan, and is interesting as throwing some light on the formation of the graphitic schists. There is, then, no break in the line of coal-bearing rocks between the crystalline schists, and the rocks bearing tertiary lignites or the recent peat beds.

The Pennsylvania geologists do not think that position, with reference to the disturbing forces that have elevated the Appalachian Mountains, will alone account for the formation of anthracite. The coal deposits do indeed become more bituminous to the west, but not in such proportion as would be expected if disturbance were the cause. The character of the strata which cover them, and the depth of burial, are of much importance in determining the present nature of coal beds.

CLAY SLATE.

The origin of slaty cleavage, except so far as that it results from pressure has never been settled. Sorby mixed micaceous hematite with clay, and by pressure he caused these scales all to assume a common position, and he argued that such pressures, acting in given directions, could give the structure to any of the schists, and cleavage to the slates by simply arranging elongated or flattened particles. This experiment has often been repeated with various modifications, and it surely is a fact that such pressures acting as indicated have produced many features that we see in the rocks. Tyndall, however, considered slaty cleavage a result of the flattening of particles. Mr. E. W. Hilgard, with agricultural ends in view, has made experiments upon the flocculation of particles, and he shows that fine sediments suspended in agitated water tend to flocculate, and form little masses which, acted upon by compression, are easily flattened. He, therefore, is strongly of the opinion that Professor Tyndall is correct. It may further be said concerning clay slates, that microscopic study has tended to modify existing opinions concerning these. They have been usually considered as hardened indurated clays, and classed among fragmental rocks. The microscope reveals in these rocks, however, crystalline elements which Kalkowski has thought he proved to be staurolite, and which have been thought by van Werveke and others to be of rutile. The fragmental nature of the rock is very difficult to establish, and with these evidences of crystalline structure there is no reason to think that most slate is anything more than an excessively fine grained kind of mica schist, made perhaps by the same forces acting in a less efficient manner.

CRYSTALLINE SCHISTS.

I think it can be said that but little progress has been made during the past two years in the study of the crystalline schists, so far as the theory of their origin is concerned. The same old arguments of the metamorphism of sediments are advanced, and they are met by the same objections. One would frequently be tempted to think, on reading treatises that deal with this subject, that the matter was clearly and well understood, yet there still remain many able scholars to whom "the crystalline schists remain," as Inostranzeff says, "lithological hieroglyphics."

Moreover, the study of the rocks themselves has been in a backward state. Lithologists have now for years been very busy investigating the eruptive rocks, and the result is that volumes of interesting information concerning their nature and composition have been issued, and a system of classification devised, which, if not satisfactory to all, is at least suited to the wants of the time. No very systematic work has thus far been attempted on the schists, and the subject is in a rather chaotic condition. Yet it can be said that more studies have been made on local groups of schists during the past two years than ever before, and many new and interesting varieties have been found, and many facts accumulated for future systematization. The following circumstances may be considered as interesting, and may indicate the character of the work performed.

Olivine has been shown to be a constituent of some hornblende schists by Kalkowsky, and a great group of stratified olivine rocks, which occur in Sweden, have been shown by Reusch, and afterward by Brogger, to belong to the crystalline schists. The time was when olivine was considered as especially characteristic of eruptive rocks, but it may be considered that it is very far from being confined to this group.

The very abundant occurrence of rutile in the schists has been shown by several writers, notably by Sauer. This has provoked much discussion, since some minerals, previously referred to Zircon, are probably of rutile. Zircon is, however, sometimes a constituent of the schists. Mr. van Werveke thinks the heart-shaped crystals in the whetstone schists may be of rutile.

It has often been assumed that the rocks composed of triclinic feldspar with members of the pyroxene and hornblende group were mostly eruptive. Even plainly stratified rocks of this kind have been considered as lava overflows or tuffs. Many studies have been made in the period under consideration which show that such rocks occur abundantly among the stratified schists. Benecke and Cohen describe such in the neighborhood of Heidelberg, and Rolle a whole series of such from the Rhätic Alps. Fouque and Levy describe such under the name of Amphibolite gneiss; Stelzner such from Lapland, and yet many others have been mentioned. It will be remembered that this is a subject in which Professors Hunt and Dana have in times past taken much interest, and the group of crystalline schists is now generally regarded as including rocks of this class. This is an advance.

Several efforts, notably by A. Sauer, have been made to show that bowlders exist in gneiss. The theories as to the original method of accumulation of gneisses would be modified by this demonstration. There still remains, however, too much diversity of opinion concerning what constitutes a gneiss. It is generally known that a purely eruptive granite can assume a stratified structure, and many writers are not clear enough in dividing such stratified granites from the group of crystalline schists. Little progress will be made till this is done. A gneiss with bowlders might be a stratified granite, and granites are liable enough to include strange rocks.

One writer has even urged that gneisses are tuff rocks. He recalls that the moon's surface, upon which water has not worked, is entirely covered with eruptive rocks and volcanic products, and argues therefrom that our oldest rocks must have been volcanic. No one knows, however, what were our oldest rocks, and it is generally supposed that the primitive rocks were early and finally buried beneath their own sediments.

In the mean time Lehmann, Heim, Baltzer, and still others have contributed to our knowledge of the mechanical distortion, the softening and recrystallizing of pebbles and solid rock masses by geological agencies.

Schists intersected by the Gotthard tunnel, schists from the Fichtel and Eulengebirge, schists in the districts of all the geological surveys have been studied and their mineral components determined. Thus our knowledge of these rocks has been much extended, and one can conclude that although no theories are generally adopted, a very long step has been taken in gathering together details of information, which will all be systematized at some future time.

LITHOLOGY.

The modern methods of lithological research and the results thereby achieved have never received much attention in annual records, nor in any popular publications. The dropped thread can therefore scarcely be with profit taken up as the science stood in 1879.

Lithology has always been recognized as an important department of geology, and the rocks were studied and systematized long ago. Now that the methods are so much improved, and questions of composition are solved with such ease, it is only a wonder to the modern students how the older students found out as much as they did. By the most laborious processes at least, the talented geologists of the past generation investigated with great acuteness and often discovered with accuracy the partial composition of the rocks.

The application of the microscope to lithology has now become an old feature. The studies by Brewster on the gems and crystals, of Sorby on crystals and on the cavities in the minerals of rocks, of Zirkel on the basalts, and very many others, have long been classic. These studies were made by persons of great experience and keen observational powers, who familiarized themselves with the objects that they studied and learned to recognize them. The great step in advance, for the aid of the new students, was made by Rosenbusch, who applied the optical principles discovered and analyzed by Des Cloizeaux to the examination of microscopic crystals as seen in extremely thin sections of rocks. Des Cloizeaux having deduced the optical properties of all commonly occurring minerals, these same properties were sought in the microscopic sections, and the determination aided by a microscope adapted to the purpose. The limited knowledge of minerals in general and the lack of knowledge of optical properties, had been the reason why the suggestion of Cordier, who in 1816 recommended the employment of the microscope in geology, had never been to any extent followed. During these last years a very respectable proportion of the geological literature published in Germany has been devoted to microscopical lithology. The study has reached a high state of perfection in France, but less of consequence has ever been done by the English or Americans. These few words may serve as an introduction to the progress of the past two years.

As one mark of interest in this subject, the change in the editorship of perhaps the most important geological magazine should be noted. The "*Jahrbuch für Mineralogie und Palæontologie,*" which for a half century had been conducted by Leonhard, and later by Leonhard and Geinitz, has now passed into the hands of a trio of editors, one of whom represents mineralogy (Professor Klein, of Göttingen), one palæontology (Professor Benecke, of Strasburg), and one of whom represents inorganic geology, and to this office Professor Rosenbusch, of Heidelberg, the eminent lithologist, was called. These gentlemen have organized a corps of assistants in the various lands, and aim to make this periodical a general exponent of progress in the subjects that they cover. They have issued two volumes during the past year, instead of one as heretofore, and it is certainly very pleasing to the students to have recourse to such an encyclopædic work now that mineralogical and geological literature is so extensively published in a multitude of often inaccessible magazines and proceedings of societies.

The first treatise that has ever been written upon lithology in the English language has appeared. There have heretofore, it is true, been translations, notably of von Cotta's work, and little chapters in geology have been devoted to lithology; but von Cotta's book is old, and the chapters in geological works laid claim to few pretensions. The new book is by Frank Rutley, and was published in London. To be sure, it is very poor, and is mostly abstracted from the writings of Germans, but it is beginning to be improved upon.

In this country, within the past two years, interesting miscroscopic lithological work has been done by gentlemen connected with the Wisconsin geological survey, and some initiative attempts have been made upon rocks in Pennsylvania and Massachusetts. I have already referred to the first, and the latter are hardly in a condition to be reviewed yet.

One of the most important additions to lithological literature during the past two years is the volume on *Minéralogie Micrographique Roches Éruptives Francaises*, by Fouqué and Levy. The volume, though large, is, however, simply an introduction, and treats of microscopic minerals and methods of investigation. The volume is accompanied by a large atlas of fifty-five plates; this contains lithographic and photographic reproductions of sections as seen under the microscope—pictures which in beauty and accuracy have never heretofore been equalled.

A question extensively handled in this volume is the means for the determination of optical properties in chance sections, while the work of Rosenbusch aimed more to show how one might find sections cut in definite directions, and then determine their optical properties. By a very elaborate study, Fouqué and Levy deduce what properties sections should have which might be cut in a multitude of ways through a crystal of a given kind. This subject for the feldspars had been earlier opened by Professor Pumpelly, in our country.

Yet however accurate these calculations may be, and how far beyond criticism are the results, there are many practical difficulties which will cause this method to be applied only to a most limited extent. Much more practical and fruitful in results is the method which, though not original with him, Thoulet has applied to the mechanical separation of rock ingredients. A solution of the iodide of potassium will dissolve mercury iodide, and the resultant fluid is heavier than the more common rock ingredients, which consequently will float upon it. By addition of water the density of this fluid can be reduced to any desired point, and the various constituent minerals that compose the powder of a rock which is thrown into and mixed with this fluid can be made to settle out one by one in a state of purity and fit for analysis. This method has already yielded practical results; one of these is the demonstration that rocks are even more complex in mineral composition than had been supposed.

This brings us back once more to the question of the feldspathic constituent of rocks, which is of much importance, because feldspar is the most generally distributed of all rock constituents. Many methods have been proposed for their determination. Optical methods usually allow potash feldspar to be distinguished from the other species, but if more than one of the other kinds be present, optical methods only allow the one with greatest obliqity of elasticity planes to be determined. Consequently, rocks have been usually determined as being composed of one species of triclinic feldspar with other minerals, or of one species of triclinic feldspar with orthoclase and other minerals. Fouqué, in his work on Santorin, indicated that the feldspathic constituent of rocks was more complex, and the application of the specific gravity fluid bids fair to prove that this complexity is quite general.

CONTACT PHENOMENA.

But the determination of the mineral composition of rocks is not the highest end of microscopic work. The mere enumeration of the components of various stones can prove wearisome in the extreme. When the microscope comes to aid in the solution of geological problems, then its developments become of the greatest interest. It has been applied with greatest success in the study of the changes induced on schists and stratified rocks by the influence of eruptive masses. The study of these so-called contact phenomena had been pursued by students such as Daubrée and Lossen, in the field, with most satisfactory results, but it never became so interesting as when Rosenbusch applied the microscope and chemical analysis to the study of the rocks that lay against the granites in the Vosges.

Another remarkable case of contact has during the past year been studied and described by myself. In the celebrated Crawford Notch of the White Mountains an immense mass of granite, many square miles in extent, comes in contact with an area of hydrous schists. If one approaches this contact from the side of the granite, most marked changes are seen to take place, and changes of such a nature that the granite would not be recognized as such in the neighborhood of the contact. In fact, it becomes a quartz porphyry. But the microscope and analysis prove that it is the same granite only modified in the style of its crystalization by the quicker cooling induced by the cold walls. On the side of the schist, however, not merely have the rocks been physically altered by the heat of the granite, but they have been materially altered in composition, and filled with new minerals by reason of an impregnation with vapors and solutions brought up and forced far into them by the eruption of the granite. The granite upon the contact is mixed with fragments of various kinds of schist which were torn from the walls as the molten rock ascended, and the granite has in places thrown long arms out into the schist. There are seven distinct zones marked by different minerals and structural features between the granite and schist, and these zones have definite boundaries and owe their origin to the contact. This same granite in meeting the schists at another point has induced the same series of zones, but the zone of mixed schists and granite is mountain great, forming, in fact, Kearsarge and Moat Mountains. I speak of this study as a stage of progress because contact phenomena have received little attention in America, and the features that determine the eruptive nature of a granite have been ill defined. Granite means almost anything in this country, and most of the granite masses, including this one, have by some been classed among metamorphic rocks. Internal structure and lines of stratification, which granites frequently present have been considered as evidences of sedimentary and metamorphic origin, although it is well known that volcanic products are often stratified.

Evidences of the origin of many such rocks are to be obtained by the study of contact phenomena, and the true line of division between granite and gneiss is to be thus deduced.

EXPERIMENTAL GEOLOGY.

There has of late years been much less interest felt in speculative geology; or rather, it has been the tendency to bring geological phenomena more easily within the limits of common comprehension by showing that analogous effects can be produced by very simple causes that are within our control or limits of our observation. The great work by Charles Lyell on the principles of geology, in which he showed that the geological forces that are daily active about us, if allowed to operate a sufficient time, would produce the results that are described by geologists, was a great move in this direction, and students have been ever more and more active in attempting to reproduce phenomena seen in nature in the laboratory. Daubrée, who has been very active in this direction, has brought together all his researches into a single volume, which he calls "Synthetic Studies upon Experimental Geology." Here one finds the results of his celebrated studies on the minerals formed by the hot water in the old Roman baths, on the minerals formed in sealed tubes containing very hot water, and on the production of minerals by processes of sublimation. Here, also, are detailed the results of experiments designed to stratify plastic materials in imitation of rocks, to joint and cleave rocks as it is done in nature, and results of experiments designed to form artificially products of the nature and composition of meteorites. The book is a fascinating one, and contains in addition many new facts.

Besides this voluminous work, many contributions have been made to experimental geology, some of which are referred to under the head of mineralogy. It is proper to notice here the circumstance that Fouqué and Levy have accurately reproduced leucitic lavas like those that have issued from Vesuvius, as well as nephelin-holding and other common volcanic rocks. This is interesting, because leucite passes as an infusible mineral, and for this reason, and because it is not always the first mineral to crystallize in these rocks, the question has been discussed whether these lavas result from a purely igneous fusion. So far as the possibilities of the case are concerned, the question may be regarded as settled.

EOZOON CANADENSE.

Perhaps no question in American geology has excited such long and bitter controversy, participated in by students who have considered it from such varied standpoints, as the question of the organic or inorganic nature of this form that has been found in the rocks of various lands. Those who have believed in it most fully have been those most familiar with its mode of occurrence, and this has always strengthened their case, supported as it has been by eminent zoölogical authority. Yet mineralogists have never found it difficult to explain its formation by purely inorganic forces. Perhaps the question has never been so near settlement as when, shortly ago, Karl Möbius, professor of zoölogy at Kiel, published a most exhaustive study of specimens obtained in part from the original describers. He concluded, after careful microscopic study and comparison with assumed allied forms, that there is nothing to justify the supposition of its organic nature. His opinion was, indeed, not of sufficient weight to convince those of fixed opposite opinion, neither will probably agreement be ever reached in this generation, for, as the believers in it say, the evidences are before us and we have but to form our judgment.

SUBMARINE GEOLOGY.

Mr. Alexander Agassiz, incidentally to his work of dredging in the deep waters of the Atlantic, has found that shallow waters connect the West Indian islands with the South American continent, and this, together with the notable fact that the flora and fauna of these islands are related to those of Central America, and not to those of the southern United States, indicate that in past time these were very probably a part of the southern continent. This may be considered as another addition to geology, gained by the investigation of the ocean's bottom, so many of which were gained by the British expeditions. Professor Verrill has found tertiary fossiliferous rocks by dredging off the northern coasts.

CHEMICAL GEOLOGY.

The work upon general and chemical geology by Justus Roth, one volume of which is now issued, will be a most important addition to literature. This first volume treats of the formation and decomposition of minerals, of spring, river, and sea water, and their depositions. It contains in abstract, with references, all the work which, up to the present time, has been done upon these subjects, and contains, besides, many original contributions. Indeed, this work promises in all its parts to form a kind of compendium of the science, which is much needed.

AMERICAN ASSOCIATION.

The American Association for the Advancement of Science met this year at Boston, and the number of papers presented upon geological and mineralogical subjects was so large that a permanent subsection was organized to accommodate those especially interested in these sciences. The election also of Professor Brush, one of our most distinguished mineralogists, to the office of president of the association is an indication of the appreciation by the association of labors in these departments.

PHYSICS.

BY GEORGE F. BARKER,

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GENERAL.

Great activity has been manifested in physics during the years 1879–'80. New and important discoveries have been made, improved modes of research have been devised, greater accuracy has been attained in measures of precision, and more uniform and precise standards have been adopted as units. Sainte-Claire Deville and Mascart communicated to the International Geodetic Association an elaborate paper describing the construction and giving the properties of the new platinum-iridium standard of length. The alloy was made by Johnson, Matthey & Co., by fusing together 450 ounces of platinum and 55 ounces of iridium. After suitable working, it was drawn through a draw-plate into a bar accurately rectangular in cross-section. Its density now was 21.51; and it was found to contain platinum 89.41, iridium 10.19, rhodium 0.17, ruthenium 0.10, iron 0.06. This alloy is harder and more resistant than platinum, is much more rigid, and has a high elasticity, its modulus being 21,912,000,000, and its elongation-coefficient 0.0003. Its coefficient of expansion was in course of determination by Mascart, the elaborate preliminary measurements only being described.—(*Ann. Chim. Phys.*, V, xvi, 506, April, 1879.) C. S. Peirce has reported progress in the comparison of a wave-length with a meter. Using a Rutherford ruled plate of 340½ lines to the millimeter, three complete measures of Van der Willigen's spectrum line No. 16 gave for the angle of double deviation as a mean 89° 54′ 19″.5 An error of 0″.4 would make an error of a micron in the length of the meter. Subsequently another line near the former one was selected, and a finer plate was used. As a mean of six closely accordant measures, the double deviation was 90° 03′ 51″.45. One of these plates had been compared with all the centimeters of a decimeter scale. The other is to be compared with the even two centimeters of the same scale. This decimeter scale was in progress of comparison by Mr. Chapman with the decimeters of a meter scale. When done, a meter will have been compared with a wave-length.—(*Am. J. Sci.*, III, xviii, 51, July, 1879.) W. A. Rogers has communicated valuable papers on metrological subjects, among which may be mentioned those on "The limits of accuracy in measurements with the telescope and the microscope" (*Proc. Am. Acad.*, II, vi, 168), on "Standard measures of length," and "On two forms of comparators for measures of length" (*Am. Q. Mic. J.*, January and April, 1879), and "On the present state of the question of standards of length."—(*Proc. Am. Acad.*, II, vii, 273.) More recently this physicist has described the construction and early performances of a new diffraction ruling-engine, which promises most valuable and important results.—(*Am. J. Sci.*, III, xix, 54, January, 1880.) Hilgard has published, under date of July 10, 1880, an admirable report upon the methods and results of a comparison of the American and British standards of length, intended to form Appendix 12 to the Coast Survey Report for 1877. The final conclusions with reference to the American standards are that bronze No. 11 is standard at 62°.25 F., iron No. 57 at 62°.10 F., and the mean yard of Troughton scale at 59°.62 F.

With reference to the molecular constitution of matter, Sir William Thomson has continued his researches upon the "Vortex atom theory," and has communicated to the Royal Society of Edinburgh papers upon "Vortex statics" and upon "Vibrations of a columnar vortex," in which the treatment is mathematical.—(*Phil. Mag.*, V, x, 97, August, 1880.) Tolver Preston has discussed the physical aspects of the vortex atom theory, with a view to reconcile the proved indestructibility of the atom with its capacity for executing vibrations. He illustrates the motion of the material forming the vortex atom by supposing a cylinder of India rubber to be rotated about its longitudinal axis, and then, while still rotating, to be bent into the form of a ring and the ends joined. Such a portion of moving matter, mathematics has proved to have all the qualities of a solid. It is elastic, and is competent to execute vibrations of definite periods. Moreover, it is incapable of being divided or severed by the collisions of other similar atoms. In short, such vortex atoms are elastic, indestructible bodies, capable of rebounding from each other without loss of energy, and of executing vibrations of fixed periods.—(*Nature*, xxii, 56, 1880).

Rühlmann, from considerations founded on Avogadro's law, has given some calculations on the dimensions of molecules. The radius of the sphere of action for the nitrogen molecule he gives as 34×10^{-9} centimeter; for the carbon dioxide molecule, 16×10^{-9} centimeter; and for the hydrogen molecule, 41×10^{-9} centimeter. Since one cubic centimeter at 0° and 760^{mm} pressure contains nearly 100 trillions of molecules, it follows that the molecules themselves fill only about the three-thousandth part of the entire volume which the gas occupies. The author gives 15×10^{-23} gram as the absolute weight of a hydrogen molecule, and 360 as the specific weight.—(*Beibl. Ann. Phys. Chem.*, No. 2, 57, 1879.) Hodges has also given a computation of the size of molecules, based on the work required to convert water into steam, this conversion being considered as a breaking up of the water into a large number of small parts, proportionally increasing the total surface. Supposing the molecules to be spherical, he gets for their radius 0.000000005^{cm}, or 5 to 6 (million)^3 for the number in one cubic centimeter; agreeing with the results of Thomson and Maxwell.—(*Am. J. Sci.*, III, xviii, 135, August, 1879.) In a subsequent paper, the same author gives a calculation of the mean free path of the molecules in the vapor of water lying close to the liquid surface, which he finds to be 0.0000024^{mm}.—(*Am. J. Sci.*, III, xix, 222, March, 1880.)

MECHANICS.

1. *Of Solids.*

The motions of finely divided solid particles when immersed in liquids, commonly called the Brownian movement, and those of dust-particles in air, have both been attributed to the same cause, the shock of colliding molecules. Nägeli has calculated from the data of the kinetic theory what the velocity of the smallest fungus-particle observable with the microscope should be, supposing an oxygen or nitrogen particle to come in collision with it. Since such a particle is 300 million times heavier than the molecule, the velocity would not be greater than that of the hour hand of a watch. For ordinary motes, the motion would be 50 million times slower. The same results essentially were obtained for liquids; whence the author thinks the Brownian movements are phenomena connected with the surface tension of the liquid.—(*Ber. Ak. München*, 1879, 389.)

Buchanan has communicated to the Royal Society of Edinburgh a paper on the compressibility of glass, using a rod of this material placed in a receiver of steel with glass ends connected with a hydraulic pump. The compression is read by means of micrometer microscopes, and the pressure is determined by a manometer consisting of a mercurial thermometer with a stout bulb, previously calibrated in a piezometer, the bulb being immersed in the water under pressure, while the stem projects outside. The glass used was a flint glass, and the compression was observed up to 40 atmospheres. The cubical compression observed was, for each atmosphere, 2.92 parts in a million. Incidentally the compressibility of water at 2°.5 C. was found to be 0.05160 volume per thousand per atmosphere; and its diminution with rise of temperature was confirmed, being 0.04831 at 12°.5 C.—(*Nature*, xxii, 377, 1880.) Barus has studied the influence of hardness upon the thermo-electric properties and the specific resistance of steel. The steel used was in the form of wire and was hardened by heating it by an electric current, in a glass tube through which a stream of carbon dioxide gas was passed and then suddenly admitting water. The resistance and the electromotive force vary with the hardness, so that if the electromotive force be taken as a measure of the hardness and the magnetic constant of the steel, the resistance is a linear function of it.—(*Phil. Mag.*, V, viii, 341, November, 1879.) Marangoni, with reference to Bottomley's experiment of passing a wire through ice without cutting it in two, divides plastic substances into two classes. Those belonging to the first class, can, like ice, be cut in two with a metallic wire, and can be considerably deformed. To this class belong plastic clay, fresh soap, camphor, black pitch. Substances classed in the second group give two lamellæ on the two sides of the cutting wire, which then come out of the slit, become notched and bend over, resembling leaves. Examples of this class are found in vegetable Japanese wax, dry Marseilles soap, tallow, and stearin, and especially yellow wax and paraffin. The success of the experiment depends on the size of the wire and on the temperature. For yellow wax, the wire should be from ½ to 1^{mm}. diameter; for paraffin ½ to 0.9. The leaves with the former are produced between —8° and 40°, with the latter (melting at 43°.5) only up to 15°. The author calls attention to the similarity between these lamellæ and those separated from a rail when a locomotive goes down a steep incline rapidly and with a powerful brake applied.—(*Nature*, xxi, 21, 1879.)

Herschel has published a paper on the use of the seconds pendulum for determining the figure of the earth, in which he comes to the conclusion that the experiments made hitherto are of little use, since the problem to be solved was so imperfectly grasped. The use of the absolute pendulum contemplated two distinct objects which had no essential connection, the force of gravity and the figure of the earth; while the use of the differential pendulum contemplated only one. The rate of the seconds pendulum varies along the actual equator, and the value of gravity at the equator is therefore only an idea.—(*Nature*, xxi, 599, 1880.) C. S. Peirce has given the results of his pendulum experiments made under the direction of the Coast Survey. The values obtained were: At Hoboken, 0.9932052^{m}; at Paris, 0.9939337; at Berlin, 0.9942399; at Kew 0.9941776. Reduced to the sea-level these numbers become 0.9932074, 0.9939500,,0.9942482, and 0.9941790. Reduced to the equator, they are: 0.9910003, 0.9910132, 0.9909865, and 0.9910083. These values, the author thinks, will have to be diminished by about 20 microns on account of the error of the standard of length employed.—(*Am. J. Sci.*, III ,xx, 327, October, 1880.) Mendenhall has made a series of experiments to determine the force of gravity at Tokio, Japan. In the earlier part of the investigation a Kater pendulum was used; in the latter, one of Borda's construction. The beats were recorded upon a chronograph at the same time with those of a break-circuit clock, the length of one second upon the sheet being about 8^{mm}, so that it could easily be subdivided. Since it was only the fractional part of a second by which the two pendulums differed, that was to be determined, the standard pendulum was only required to break the circuit twice, once at the beginning and again at the end of the experiment. As a mean of six experiments with the Kater pendulum the value of "*g*" was found to be 9.7974; the mean of eleven experiments with the Borda pendulum gave 9.7984.—(*Am. J. Sci.*, III, xx, 124, August, 1880.)

Deprez has contrived a new velocity-regulator for electric motors. It consists essentially of an elastic spring, fastened at one of its extremities to the rotating axis and parallel to it. To the other end is attached a small mass of brass traversed by a screw by which its distance from the axis may be adjusted, and the tension of the spring at the same time increased. The current which drives the motor passes through this spring. If now the rotation is so rapid that the free end of the spring is thrown away from the axis by the centrifugal force, the contact is broken and the current is interrupted; the speed of the motor is diminished, contact is renewed, and so on, the velocity being exactly regulated by the adjusting screw.—(*J. Phys.*, viii, 10, January, 1870.) Fonvielle has devised a form of gyroscope whose rotation is produced by magneto-electric currents. A flat coil of wire, like that used in galvanometers, has an intermittent current sent into it from an induction coil. When a star-shaped piece of iron, mounted on a pivot so as to rotate like a compass-needle, is placed in the center of the coil, it begins to revolve whenever a horse-shoe magnet is placed above it vertically, or when a bar magnet is placed in certain directions with reference to it. Reversing the direction of the current reverses the direction of the rotation.—(*Nature*, xxi, 593, April, 1880.)

2. *Of Liquids.*

Rudorff has described a special form of volumenometer used by him for the determination of the specific gravity of powders. The new apparatus is composed entirely of glass, and consists of a cylindrical reservoir of 25^{cc} capacity, from the lower part of which a tube passes, this tube being enlarged just below the reservoir, and having a cock at its lower end. The reservoir is closed at top by a ground stopper furnished with a stopcock, and to it laterally is attached a long U-shaped manometer tube. Mercury is poured into the reservoir until the tube is filled to the mark on the neck. The upper cock is closed and the mercury drawn out into a tared vessel till the difference of level between the two mercury surfaces in the manometer is a certain quantity h. After the mercury is weighed it is poured back into the tube, the substance whose specific gravity is to be determined is introduced into the reservoir and the above operations are repeated. Simple calculation gives the value required.—(*Ann. Phys. Chem.*, II, vi, 288, 1879.) Buignet has improved the Nicholson areometer by making the stem longer and larger, marking zero at the point to which it sinks in water when empty, and n at the point to which it sinks when loaded with n grams. To use it, the instrument is placed in water and sinks to zero. The mineral whose gravity is desired is placed on the upper pan; the stem is immersed to a point P. Placed in the lower pan, it sinks the stem to a point, P′. Then $\frac{P}{P-P'}$ is the density of the specimen. The sensitiveness of the instrument depends on the size of the stem. Its use is rapid and accurate.—(*J. Phys.*, ix, 93, March, 1880.)

Spring has continued his investigations on the welding of solid bodies by pressure, and has now subjected more than eighty pulverized solids to pressures *in vacuo* up to 10,000 atmospheres, varying at the same time the temperature. All the crystalline bodies proved capable of welding, and in the case of amorphous bodies, crystalline structure had been developed in the block by the pressure. He classifies amorphous bodies into two groups, one like wax and called ciroid, which weld easily, the other like amorphous carbon, which do not weld, and hence called aciroid. The facts observed do not essentially differ from those observed when two drops of a liquid meet and unite. Hardness is a relative, even a subjective, term. Even water may appear hard to certain insects, and if our bodies were sufficiently heavy, the pavement would not bear us. The change of prismatic to octohedral sulphur, of amorphous to metallic phosphorus, by compression, the change of state of amorphous bodies, the chemical action produced when the product has a less volume than the constituents, all result in a denser form of matter. Whence the conclusion that the particular state taken by matter is in relation to the volume it is obliged to occupy under the action of external forces. The geological bearing of these facts is very evident.—(*Nature*, xxii, 350, 1880.)

Ridout shows the surface tension of mercury by supporting a shallow tray, 6 by 3 inches, on leveling screws, so inclined that the mercury is on the point of overflowing. If now the flow of the mercury be started, it will draw the rest of the liquid after it. The mercury must be very pure or it will leave a trail.—(*Nature*, xxii, 157, 1880.)

Lechat has studied the forms produced when liquids are caused to vibrate in vessels of rectangular section, and has compared the results obtained with those required by theory. The vessels employed were made of wood or glass, with walls a centimeter thick. The liquid was vibrated by a bar of steel placed before an electro-magnet, which bar automatically interrupted the current. To one end of a transverse rod a stem was attached which could be adjusted to any point of the surface. The nodal lines were very distinct, and the phenomena were very striking, especially when projected on the screen.—(*J. Phys.*, ix, 185, June, 1880.)

Sir William Thomson read a paper to the British Association on a septum permeable to water but not to air, and suggested its application to a gauge for measuring depths. A small quantity of water in a capillary tube, with both ends in air, acts like a perfectly air-tight plug against difference of pressure at its two ends equal to the hydrostatic pressure corresponding to the height at which water stands in the same capillary tube when it is held upright with one end under water and the other in air. In the meeting, he used an Argand-lamp chimney which had a finely-woven piece of cotton cloth tied over it. When dry, the water rose easily when the uncovered end was immersed, as well as when the covered one was. But after wetting the cloth, it seemed perfectly air-tight even under 9 inches water-pressure. The depth-gauge is made by tying a piece of cloth over the mouth of the larger leg of a U-tube, the end of the smaller being closed by a stopper. On sinking it the air is compressed, and water enters through the cloth into the smaller leg. On raising it the air expands and forces the water out through the cloth to the last drop. The depth can be determined from the water left in the smaller leg of the instrument.—(*Nature*, xxii, 548, 1880.)

3. *Of Gases.*

Hannay and Hogarth have communicated to the Royal Society a remarkable paper on the solubility of solids in gases, the research being the starting point of the experiments which have since enabled the former to produce crystallized carbon. They desired to investigate the solvent power of liquids at temperatures at or above their critical points. For if at the critical point there really occurs a transition from the liquid to the gaseous state, and if the property of dissolving solids is one possessed by liquids alone, there ought to be precipitation of the dissolved solid matter as the substance passes through the critical point. Absence of such precipitation would furnish a strong independent proof of the perfect continuity of the liquid and gaseous states. As a preliminary test, a solution of potassium iodide in alcohol was prepared and a strong tube one-half filled with it. No precipitation of any solid was observable even at 350° C., more than 100° above the critical point of alcohol. Resin dissolved in paraffin spirit showed no decomposition at 360°. With an improved and simplified apparatus, it was shown that a clean crystal of potassium iodide dissolved entirely in alcohol gas (the term "gas" referring to the fluid above its critical point). Potassium bromide and calcium chloride were also soluble in this gas. Cobaltous chloride remained soluble at 320° and showed its blue color and characteristic spectrum. Even the acid decomposition-product of chlorophyll, which decomposes in the air below 200°, gives, when dissolved in alcohol, identical spectra at 350° and at 15° C. Some curious reactions were observed. Thus alcohol or ether deposits ferric chloride just below the critical point, but redissolves it in the gas when raised 8° or 10° above that point. By suddenly reducing the pressure, the solid is precipitated crystalline, falling as a snow. It is redissolved in the gas as the pressure increases.—(*Proc. Roy. Soc.*, xxx, 178; *Nature*, xxi, 82, 499, 1880.)

Bottomley has described a neat experiment by Quincke, first suggested by some experiments to test the porosity of glass. A glass tube, 5 inches long and three-fourths inch external diameter, with stout walls, was closed at one end and constricted a little more than half way up. Into the lower closed portion some sulphuric acid was poured, and above the constriction some fragments of marble were placed. The tube was then drawn off at top, thickened, and carefully annealed. On inverting it the acid attacked the marble, and carbon dioxide was evolved. For the first few days nothing peculiar was noticeable; but soon the liquid began to creep away from the glass, scarcely wetting it, and no doubt was entertained that soon the phenomenon seen in Quincke's tubes would appear, and the acid would roll about in the tube like mercury. The explanation is that these peculiar capillary phenomena are due to a thick layer of gas that is condensed over the surface of the glass.—(*Nature*, xx, 291, 1880.)

De la Rue and Müller, reasoning from their electric researches on the spark in rarefied air, believe themselves entitled to conclude on the probable height of our atmosphere. The least resistance to an electric discharge in hydrogen is obtained at a pressure of 0.642^{mm}, or 845 M (M signifying millionths of an atmosphere). When it reaches .002^{mm}, or 3 M, the discharge only just passes with a potential of 11,000 silver chloride cells (11,330 volts). At the highest exhaustion, 0.000055^{mm}, or 0.066 M, no discharge took place with the 11,000 cells, but even a 1-inch spark failed to pass. Since a discharge at atmospheric pressure which occurs in hydrogen at 0.22 inch takes place in air only at 0.13 inch, the authors conclude that the least resistance for air is at 0.379^{mm}, or 498.6 M. This pressure would be reached at a height of 37.67 miles above the sea. Hence here the auroral discharge would have its maximum brilliancy, and would be visible 585 miles. The best vacuum produced, 0.066 M, corresponds to a height of 81.47 miles. At this height the discharge would be considerably less brilliant. At a height of 124.15 miles the pressure would be only .00000001^{mm}, or 0.00001 M, and at such a height it is not conceivable that a discharge would occur with any probable potential. At a pressure of 62^{mm} the discharge has the well-known carmine tint of the aurora. This corresponds to an altitude of 12.4 miles. At a pressure of 1.5^{mm} it becomes salmon-tint, and at 0.8^{mm} much paler. Above this exhaustion it becomes a pale milky white.—(*Nature*, xxi, 33, 1880.)

Debrun has suggested an improved barometer, which he calls an amplifying barometer. It resembles the Fortin instrument in general, but the point marking the zero is at the top of the tube. The cistern has a second tube in its top, open to the air, and into which the mercury rises, so that the reading is the difference of the levels of the mercury surfaces in the two tubes. A third and narrower tube, also open at top, passes through the top of the cistern. This cistern is larger than ordinary, and contains water above the mercury, into which this tube dips, and which rises into it, the level being read by means of a graduated scale. Any variation of the height of the mercury is multiplied in the water-column in the ratio of the section of the cistern to that of the water-tube. Hence the sensibility of such a barometer is equal to that of the water-barometer.—(*J. Phys.*, ix, 387, November, 1880.)

Jordan has constructed and erected in the Kew Observatory a barometer in which the liquid employed is glycerin colored with aniline-red. As manufactured by Price & Co, the glycerin has a specific gravity of 1.26. Hence the mean height of the column is 27 feet, and a variation of one-tenth of an inch of the mercurial column is more than an inch on the glycerin scale. Moreover, the high boiling point of glycerin, 440° F., its very low vapor tension, and its low freezing point are all in its favor. The cistern in the Kew instrument is a cylindrical vessel of tinned copper, 10 inches diameter and 5 deep, with a screw cover, the air having access through a small hole in the cap of this, and passing through a layer of cotton wool to keep out the dust. The tube is of composition-metal gas-pipe $\frac{5}{8}$ inch diameter, which is soldered to a similar piece of pipe which enters the cistern through its bottom and is closed by a screw plug. To the top of the main tube, a glass tube 4 feet long and 1 inch inside diameter is cemented. It terminates in a cup and is closed with an India-rubber stopper. The fluctuations are read off by means of two verniers, one of which gives inches and tenths and the other the equivalent value of the mercurial column. Daily observations are being made upon it with a view to determine its accuracy.—(*Nature*, xxi, 377, 1880.)

Terquem has proposed a modified form of air-pump plate, which dispenses with the costly grinding necessary in the present form. The plate is of brass, circular in form and about a millimeter in thickness, having a circular cavity in it two centimeters deep and one wide, placed a few centimeters from the edge, the mean diameter of this depression being that of the bell to be used with it. When the plate is to be used it is heated and the cavity filled with a cement melting at about 60° C. That used by the author is furnished by F. Carré with his ice-pump, and consists of a mixture of resin, wax, and tallow. When melted the bell is placed in position and the heat continued until the glass has also become hot. The whole is then allowed to cool. The cheapness of these plates allows the use of several of them for the various air-pump experiments.—(*J. Phys.*, ix, 346, October, 1880.) Rood has described an improvement in the form of the Sprengel pump, by which vacua as high as $\frac{1}{90000000}$ or $\frac{1}{100000000}$ are readily obtained. First, the mercury passes through an exhausted bulb to free it from air and moisture, then through a nearly horizontal tube to the fall-tube. Secondly this fall tube is bent four times at a little more than a right angle, forming a lateral loop or valve, preventing the air that has passed out of the fall-tube from returning into it. The pump is free from stopcocks and grease, and its action is very rapid, two or three hours sufficing to reduce the vacuum from 50 M to 0.01 M, the capacity being 100^{cc}. Even in the absence of all drying materials a vacuum as high as 0.033 M has been obtained.—(*Am. J. Sci.*, III, xx, 57, July, 1880.)

Bertin, in an interesting article on the modern methods for producing high vacua, describes the McLeod gauge, that necessary adjunct to the Sprengel pump. It depends on the principle that if the volume of a rarefied gas be reduced *n* times, the pressure becomes measurable, and the original pressure is equal to the measured pressure divided by *n*. It consists of a bulb of glass surmounted by a thick tube 10 to 15^{cm} long and 2 or 3^{mm} in diameter, closed at top and carefully calibrated. Below, the bulb connects with a straight tube 80^{cm} long, a lateral tube opening into it just below the bulb and leading upward to the pump. The capacity of the bulb above the lateral opening is ascertained by weighing the mercury which fills it. Thus the ratio of the volumes of the bulb and of the small tube above it is known. The long tube is connected at its lower end with a reservoir of mercury by means of a rubber tube, so that when this is raised the gauge may be filled with mercury. After the vacuum has been made in the pump, of which the gauge forms a part, the reservoir is lifted and the mercury rises in the long tube until it passes the mouth of the lateral tube and seals off the air in the bulb. As the mercury fills the bulb, the air collects in the small tube, and the pressure under which it exists is the difference of level of the mercury in this tube and the side tube. Knowing the volumes and the final pressure the initial pressure is given by Marriotte's law. Mr. Crookes regards it reliable to the millionth of an atmosphere, 0.000760^{mm}. Warren de la Rue limits its indications at 0.00005^{mm}.—(*Ann. Chim. Phys.*, V, xix, 231, February, 1880.)

Amagat has studied elaborately the variation of gaseous bodies from the law of Marriotte at high pressures, exact measurements being made of the changes in volume when the gas sustained a mercury column over one-fifth of a mile high. The shaft of the Verpilleux coal mine, near St. Etienne, 327^{m} in depth, was chosen, the experiments here being confined to nitrogen gas. A powerful and specially constructed pump forced mercury at the same time up the manometer tube and into the tube containing the gas. Since both were carefully calibrated, the measurement in the former gave the pressure and in the latter the volume. In nitrogen the compressibility increases slowly and reaches a maximum at about 65 atmospheres. Then it decreases equally slowly, reaching a normal figure at about 91 atmospheres. Finally it decreases rapidly, till at 430 atmospheres the volume is five-fourths of that required by Marriotte's law. This law of nitrogen being ascertained, the manometer tube was replaced by a nitrogen tube and the other gases compared with that. Air, oxygen, hydrogen, carbonous oxide, ethylene, and marsh gas were examined up to 400 atmospheres. The results are given graphically, the abscissas representing pressures and the ordinates the differences between the product of the volumes by the pressures and unity, *i. e.*, to the deviations from Marriotte's law. Hydrogen only does not exhibit a minimum of volume and pressure product.—(*Ann. Chim. Phys.*, V, xix, 345, March, 1880.) Cailletet has also studied the law of the compression of nitrogen. He used a steel laboratory tube, within which was a piezometer tube containing the gas. To the laboratory tube was attached a tube of soft steel 250^{m} long, rolled upon a wooden cylinder 2^{m} in diameter. The laboratory tube was supported by a steel wire 4^{mm} diameter, carefully graduated. The gas tube being put in place, the apparatus was filled with mercury and lowered by a windlass into an artesian well. The pressure was read off on the graduated suspending wire. To determine the volume, the inside of the piezometer tube was gilded, and the height to which the mercury rose in it was shown by the removal of the gold. The measurements were carried on with nitrogen to 182 atmospheres. Cailletet has also studied the effect of pressure on gaseous mixtures, and has described a method by which a pressure of 1,500 atmospheres may be measured to within one-half of 1 per cent. of its true value.—(*J. Phys.*, viii, 267; ix, 192; *Ann. Chim. Phys.*, V, xix, 386, March, 1880.)

ACOUSTICS.

Carmichael has devised a revolving jet to be used with Koenig's manometric capsule for the purpose of showing sonorous vibrations in class instruction. A tube bent at right angles and tipped with a jet is surrounded at its extremity by a second concentric tube also bent at right angles, but in the opposite direction, so that the two bent parts are in the same line and form an axis about which the jet revolves. A mica cylinder incloses the flame, which is that of ordinary gas, enriched, if necessary, with benzene and fed with oxygen. The gas tube is in communication with a Koenig capsule, so that the flame is thrown into vibration by means of it. On rotating the jet by a multiplying wheel a brilliant ring of light appears, which is broken up into saw-teeth by sounds.—(*Am. J. Sci.*, III, xix, 312, April, 1880.)

Schwedoff has described a simple apparatus for studying the vibrations of cords, which consists in an electric vibrator like that in use for bells. The cord is attached to the armature at one end, the other being fastened to a movable clamp which slides along the top of a blackened board divided into a number of equal divisions. To the clamp the cord is attached by a screw, by which its tension may be regulated at pleasure.—(*J. Phys.*, viii, 23, January, 1879.)

Mercadier has exhibited in Paris a vibration micrometer for accurately determining the vibration-amplitude of tuning-forks and other vibrating bodies. A small piece of thin white paper bearing a fine black line is fastened to the body whose vibrations are to be measured. If this line is upright it will present, when caused to vibrate, the appearance of a pale gray parallelogram, the persistence of the visual impression being perfectly definite for the extreme positions of the vibration. To ascertain the amplitude of the vibration, all that is necessary is to measure the apparent width of this minute parallelogram in a direction at right angles to the axis of symmetry of the oscillation. To increase the precision, the reference line is set, not perpendicular to the direction of the movement, but inclined to it at a small angle. A fine scale of lines is made upon the paper parallel to the direction of the movement and a millimeter distant. The width of the parallelogram is thus read off along a straight line, which makes a small angle with its sides, thus giving the quotient of the amplitude sought by the tangent of a small angle. With this apparatus the author has studied the motions of a tuning-fork vibrating electrically.—(*Nature*, xxi, 189, 1879.)

Koenig has studied the influence of temperature on the vibrations of a normal tuning-fork. He finds that up to 50° or 60° the influence of heat upon a fork may be regarded as practically constant. Thick tuning-forks are more affected by heat than thin ones of the same pitch, showing that it is change in the elasticity rather than change in the length of the arms which is the primary cause of the change of pitch. On forks of different pitch and of not very different thickness, the effect of heat is proportional to the number of vibrations. Generally the period of vibration of a fork is increased or diminished $\frac{1}{8943}$ by a difference of temperature of 1° C. The general change in pitch of the normal fork $Ut_3 = 512$ vibrations per second at 20°, through the variation of 1° C. in the temperature, is 0.0572 vibration per second. He has constructed a fork which will give 512 vibrations at any temperature.—(*Nature*, xxii, 90, 1880.)

Kayser has also investigated the influence of temperature upon the pitch of tuning-forks. He used a method founded on the observation of the alteration of the difference of phase between two forks as the temperature varied, the forks being furnished with mirrors and the Lissajous curves observed with a telescope. He finds, (1) that the vibration number of a tuning-fork between 0° and 30° is a linear function of the temperature; (2) that the influence of temperature is greater the higher the tone of the fork, and with forks similarly arranged the variation of the vibration number is about proportional to the square root of that number; (3) that with moderate variations of temperature, such as occur in a room, the temperature affects the vibration number in the second place of decimals; and (4) that the coefficient of elasticity increases between 0° and 30° with the temperature.—(*Ann. Phys. Chem.*, II, viii, 444, 1879; *Nature*, xxi, 243, 1880.)

Ellis has communicated to the Society of Arts an important paper upon the "History of Musical Pitch." This he defines to be the pitch of the tuning-note, or that by which all other notes on an instrument with fixed tones are regulated according to some system of tuning or temperament. It is convenient to consider A as the tuning-note in all cases, though pianos and organs are usually tuned on C. In equal temperament A 444 corresponds to C 528 vibrations. In mean-tone temperament A 418 corresponds to C 500; whereas for a perfect minor third between A and C, A 440 corresponds to C 528. Before 1711, the organ-pipe was the only means of handing down pitch. Subsequently both this and the tuning-fork were thus used. Both, however, alter with temperature; the former by one vibration in a thousand for each 1° F., sharpening by heat and flattening by cold. Hence all organ pitches must be reduced to a standard temperature, 59° F. or 15° C. being recommended. The fork alters by one vibration in 21,000 for each 1° F.; flattening by heat and sharpening by cold. The various pitches of the different forks were tested by means of Scheibler's tonometer, the beats with the standard fork being carefully counted. Great variations were observed, the lowest pitch for A being 374 vibrations at L'Hospice Comtesse, Lille, and the highest 567 vibrations, the usual church pitch in North Germany in 1619, called chamber pitch by Prætorious.—(*Nature*, xxi, 550, 1880.)

Kayser, under Helmholtz's direction, has made a series of experiments to test the question whether the intensity of a sound has any influence upon its velocity of propagation. He used a tube giving a continuous note, each vibrating section of which passes through the same phase after each semi-vibration. Hence two sections passing a determinate phase at the same instant are distant from each other by a multiple of half a wave length. To render visible the vibration of a gaseous section of the tube, a small tongue was cut in a very thin plate of mica, which was cemented by one of its extremities to a copper ring sliding within the tube. This mica plate reproduced the phases of air vibration at the point where it was placed. A sliding wire controlled the length of the tongue so as to bring it into unison with the sound of the tube. Viewing a luminous point on the tongue through a vibration microscope, a Lissajous figure is formed by a combination of the two rectangular vibrations. Very minute changes of phase in the tongue produce marked changes in the figure. By displacing the mica along the tube until a given figure is reproduced, the distance moved is obviously half a wave length. If the mica tongue be fixed at the open extremity of the tube, and a movable piston be made to close the other one, the same figure is observed on the lamina whenever the piston is displaced by half a wave length. A constant sound was obtained in the tube by means of an electrically vibrated fork in front of a resonator. By varying the amplitude of oscillation, the intensity of the sound could be varied. On comparison with a divided scale, the amplitude of the mica vibrations was found to be proportional to the oscillations of the air column. As a result, the author does not find any difference in the velocity of a sound when its intensity is made to vary. Regnault's results, being obtained with waves of explosion very different in their character, do not hold good for musical sounds.—(*Ann. Phys. Chem.*, II, vi, 465, 1879.)

Jacques has experimented to ascertain the velocity of propagation of very loud sounds produced by the firing of a six-pound brass field-piece at the Watertown Arsenal, Massachusetts. A series of membranes was erected at distances varying from 10 to 110 feet from the mouth of the cannon, and in the rear of it. Each membrane consisted of a hoop 9 inches in diameter, over which a sheet of thin rubber was stretched. At the center, on the side toward the cannon, a small brass shelf was fastened, on which rested one end of a delicate steel spring, the other end being held by a separate support. These metallic parts formed portions of a continuous metallic circuit, including all the screens, and terminating in the primary coil of an inductorium. The Schultz chronograph consisted of a revolving cylinder of silver covered with lampblack, connected with one terminal of the secondary coil. The other terminal was a fine wire brought very near the surface of the cylinder. When by the motion of the membranes the primary circuit was broken, a spark passed to the cylinder and made a fine dot in the lampblack. By reference to a sinuous curve of times traced simultaneously on the cylinder by an electrically vibrated fork, the time could be measured to .00001 second. When the air was quiet the gun was fired and the arrival of the pulse at each successive membrane was recorded. By measuring the distances the velocities are readily calculated. It was found that immediately in the rear of the cannon the velocity was less than at a distance, but that going farther and farther away from the cannon the velocity of sound rose to a maximum considerably above the ordinary velocity and then fell gradually to about the velocity usually received. Hence the author concludes: 1st, that the velocity of sound is a function of its intensity; and 2d, that experiments upon the velocity of sound in which a cannon is used contain an error probably due to the bodily motion of the air near the cannon. For a correct determination of the velocity of sound, therefore, he thinks that a musical sound of low intensity must be used.—(*Am. J. Sci.*, III, xvii, 116, February, 1879.) Ihlseng under the direction of Rood has measured the velocity of sound in various kinds of wood. In his first experiments he used the method of Kundt, vibrating a rod of the given wood, 1 to 2 meters long, longitudinally, while one end of it, armed with a cork, entered the end of a glass tube a meter in length, and containing a fine powder. To the other end of the tube a piston was fitted so as to make the length used a multiple of the half wave length in air. In this way rods of cedar, white-wood, yellow and white pine, hickory, white ash, holly, mahogany, black walnut, cherry, and white oak were experimented with. In a second series of experiments a method was adopted by which the rod registered its own vibrations on a smoked-glass plate drawn rapidly across the vibrating end of the rod in a horizontal direction by means of a weight; while at the same time a tuning-fork registered the time. The conclusions given are: 1st, it is possible to measure the velocity of sound in rods with considerable accuracy by the graphic method; 2d, Kundt's method gives results which are slightly higher than those by the graphic method; and 3d, the graphic method demonstrates the existence of transverse along with longitudinal vibration and gives their ratios.—(*Am. J. Sci.*, III, xvii, 125, February, 1879.)

Kohlrausch has given a method of studying the condition of the air in a vibrating column, and of repeating the experiments of Savart and Seebeck upon the position of the fixed nodes and loops produced by the combination of the direct and the reflected sonorous waves. For this purpose a caoutchouc membrane, stretched upon the extremity of an open tube, is lowered into the organ-pipe which is sounding, by means of a string passing through the cork closing the pipe. In this case the membrane is in contact on both sides with the air in the pipe, and it vibrates at the loops and ceases at the nodes. But if the second end of the tube carrying the membrane be closed with a cork, the membrane is now in contact only on one side with the air in the pipe, and it vibrates strongly at the nodes and ceases to vibrate at the loops. Seebeck explained this by showing that one of the waves was obliged to go round the tube to reach the membrane, and thus its velocity changed sign. Bichat, in noticing this paper, gives the method he has used for showing this result in class instruction. He uses the ordinary closed organ-pipe with a glass side, made by Koenig. On urging the blast a sound is obtained having a node at about one-third of its length from the mouth and a loop at one-third from the closed end. A membrane of gold-beater's skin, attached to a rigid ring, is first passed through the tube to show in the usual way that the sand placed upon it is disturbed at the loops and not at the nodes. Then a small manometric capsule is used in place of the membrane, having two small glass tubes passing from its top through the cover of the pipe. Through one of these coal gas enters, and at the outer end of the other it is burned. On examining this flame in a revolving mirror it will be seen to be in vibration when the capsule is at the node, and at rest when at a loop.—(*Ann. Phys. Chem.*, II, viii, 384; *J. Phys.*, ix, 102, 1880.)

Mayer has applied the principle of exploring the wave-surface in air from a sounding body, which he devised some years ago, to the construction of a simple and efficient apparatus called a topophone, by which even the unpracticed ear may determine accurately the direction of a distant sound, even in foggy weather. It consists of a vertical rod passing through the roof of the deck-cabin of a vessel, for example, approaching the coast, bearing upon its upper end a horizontal bar carrying two adjustable resonators below which is a pointer set at right angles with the bar. Rubber tubes from the resonators pass through the roof of the cabin and unite in a single pipe connected with a pair of ear-tubes. The vertical rod is turned in any direction by means of a handle. The resonators are first accurately tuned to the sound under observation. They are then fixed at a distance from each other somewhat less than the wave-length for this sound, and brought by turning the handle simultaneously on the wave-surface. As they now receive the sound-wave upon their mouths at the same instant in the same phase, the ear will hear the sound re-enforced if the connecting tubes are of the same length, and diminished if one is a half wave-length shorter than the other. When this is attained the bar is a chord in the spherical wave-surface of which the sounding body, say a fog-horn, is the center. Hence the pointer which is perpendicular to this bar points out the bearing of the fog-horn with great accuracy. By making a second observation at a known distance and direction from the first, a second radius line is obtained, and the distance of the fog-horn is computed.—(*Nature*, xxi, 385, February, 1880.)

Schellbach and Boehm have proposed a simple experiment for showing the refraction of sound-waves. In an inverted bell-jar of glass is placed a horizontal disk of smoke-blackened paper. A circular collodion membrane is arranged above it, inclined 33° to the plane of the edge of the bell. If now on the axis of this membrane, and at 13 centimeters distance, an electric spark be produced, the membrane vibrates and the waves which it produces make a series of concentric circles upon the paper, the center of which is on the axis of the membrane. If the bell be filled with carbon dioxide the center of these circles is displaced in the direction required by refraction and by a quantity corresponding to the sonorous refractive index. Hydrogen gas may also be employed. —(*Ann. Phys. Chem.*, II, viii, 645, 1879.)

Rood, in studying the action of a revolving fan introduced into melodeons for the purpose of producing a "tremolo" effect, ascertained that the variations in loudness produced by it were due to reflection or non-reflection from the face of the revolving fan, and that the same effect could be obtained from a disk consisting of closed and open sectors and revolving in its own plane. With this simple apparatus the following points were established: (1) At a perpendicular incidence the short sound-waves are more copiously reflected than those that are longer, and the regular reflection is more copious from large than from small surfaces. (2) When the sound-waves fall upon small flat surfaces at an acute angle, the reflection is most copious in the same direction as with light, but the reflected and inflected waves can be traced all around the semicircle. (3) Qualitative comparisons between the power of different substances to reflect sound can easily be made. (4) If a composite sound-wave falls on the rotating disk, the shorter waves will undergo regular reflection more copiously than the other components. (5) The reflection of sound from very small surfaces is easily demonstrated.—(*Am. J. Sci.*, III, xix, 133, February, 1880.)

Rhodes has devised a simple apparatus to aid the deaf in hearing, called the audiphone. It consists of a thin flexible sheet of hard ebonite rubber, provided with a handle like a palm-leaf fan, and with a cord which can be tightened at pleasure to curve it into the form of a semicylinder. The edge of the sheet is pressed against the upper set of teeth, the convex surface being outwards, so that vibrations impinging upon the sheet are transmitted through the teeth and bones of the skull to the auditory nerve. Its use, therefore, is limited to cases where the nerve is nearly or quite intact. Colladon has replaced the costly ebonite by a sheet of fine elastic cardboard, about 18 inches by 10, and varnished at the edges, which is curved by being pressed against the teeth by the hand. Experiments made with it upon deaf-mutes were highly interesting. A professional musician, deaf for fourteen years, was enabled by this audiphone again to hear piano music. Fletcher, in further experimenting, prefers birch-wood veneer cut to an oval 12 by 8½ inches, steamed and bent to a curve. It is held between the teeth. In his experience any audiphone is a failure in two-thirds of the cases of deafness in which it is tried.—(*Nature*, xxi, 426, 469, 515, 1880.)

Sedley Taylor has given the name phoneidoscope to an apparatus for studying the character of sound vibrations by causing them to act on a liquid film thin enough to give color, such as a film of glyceric liquid. Guebhard has proposed a modification of the method by which he has obtained some very curious results. Beautiful interference rings are produced by the condensation of the vapor of water upon the freshly cleaned surface of a very impure mercury. When, for example, the various vowel sounds are emitted above such a mercury surface, with a pure tone maintained for some seconds, at a distance so small that the vapor of water contained in the breath has not time to diffuse, a series of figures are obtained which are characteristic. Figures are given of the ten principal vowel sounds thus produced. The four nasal vowels give more complex figures.—(*J. Phys.*, ix, 242, July, 1880.)

Barlow has constructed an apparatus for recording the sounds of the human voice, which he calls a logograph. It consists of a small trumpet-shaped mouthpiece, the larger extremity of which widens to a diameter of 7 centimeters. Over this end is fastened a thin caoutchouc membrane. A light arm of aluminum is fastened at one end to the frame, and the other, which presses against the center of the membrane, with which it is movable, carries a small brush containing color. A band of paper, like that used in the telegraph, passes beneath, so that the point of the brush just touches it, and traces a line upon it when the membrane is at rest, which is a zero line. There is a small lateral opening in the mouthpiece for the escape of the air. Various examples are given of the results obtained in using the logograph for spoken language.—(*J. Phys.*, viii, 78, March, 1879.)

Dvorak has observed that light resonators of glass or metal are repelled very decidedly when they are brought near to the resonance box of a fork turned in unison with them. The condition essential to the success of the experiment is that the air of the resonance box shall be really in vibration. A metallic disk in unison with the resonator may also be used as the vibrating body. The repulsion thus produced is so strong that when a mill is constructed with four resonators at its ends and placed before the resonance box of a large fork, the mill revolves. Mayer independently discovered the same phenomenon.—(*Phil. Mag.*, V, vi, 225, 1879.)

HEAT.

1. *Thermometry and Change of State.*

Benoit has described a new temperature-regulator based upon the principle of the variation of the tension of a saturated vapor with the temperature, first employed by Andreæ. The apparatus consists of a small bulb, containing the volatile liquid, placed in the space whose temperature is to be maintained constant. The end of the tube on which this bulb is blown is connected with a gas-interrupter by means of a rubber tube filled with mercury. This interrupter consists of a glass tube over the lower end of which the rubber tube slips, within which is a second glass tube conveying the gas, and which continues down nearly to the mercury level. The gas enters by this tube, escapes at its lower end, passes up between the two, and goes to the burner through a lateral tube. If the temperature rises too high the mercury column cuts off the supply of gas by the increased tension of the vapor; a by-pass preventing complete extinction of the flame. The interrupter is attached to a board which slides up and down along a graduated scale, by means of which the pressure upon the volatile liquid can be made to balance its tension at any temperature. Using methyl alcohol, for example, its tension at 10° C is 50^{mm}, at 50° is 382^{mm}, at 70° is 857^{mm}, at 100° is 2405^{mm}. So that with this liquid constant temperatures between these extremes may be had. For other temperatures other liquids more or less volatile than methyl alcohol can be used in its stead.—(*J. Phys.*, viii, 346, October, 1879.)

Edison made use of his tasimeter for measuring the heat of the solar corona at the eclipse of July, 1878. In an account subsequently published he gives figures of the instrument and describes the method of using it. A carbon button is inclosed in a heavy metallic semi-conical box. Upon this button rests a metallic plate holding the lower end of a strip of vulcanite, the upper end of which is held by a screw which is capable of nice adjustment. When radiant heat is allowed to fall on the vulcanite strip, it expands and produces pressure on the carbon, thus reducing its resistance and causing an increase in the strength of any current which may be flowing through it at the time. Ordinarily the tasimeter is made one side of a Wheatstone bridge. To balance it, at Rawlins, a method of "fractional balancing" was devised, which consisted of a rheostat formed of an iron wire, No. 24, 4 feet long, wound between two rows of pins on a board, used as a shunt around the galvanometer. When the pins of one row were all connected by a piece of copper wire, the resistance of the shunt was so low that only a feeble current passed through the galvanometer, and it was easy to balance it by adjusting the tasimeter. The copper wire was then taken off a single pin, increasing the resistance of the shunt by $\frac{1}{50}$ ohm, and the spot of light, deflected nearly off the scale, was again brought to zero. And so on until the whole shunt was removed, and the whole current was used on the galvanometer. Its sensitiveness was now adjusted by raising the damping magnet until the top of the rod was reached. In this condition it easily indicated the heat of Arcturus focused on the vulcanite by a 4-inch object-glass. But upon the corona the deflection was so violent that the spot of light passed off the scale not to return.—(*Am. J. Sci.*, III, xvii, 52, January, 1879.)

Ridout proposes to show the expansion of glass, as a class experiment, very neatly, by bending a glass tube of small diameter and 18 inches long into the form of a horseshoe, so that the free ends approach each other within a millimeter. Springing these ends apart and introducing a coin, it will be held there owing to the elasticity of the glass. On warming now the outer surface of the glass it expands and the coin drops out. Le Conte, apropos of this, gives an equally striking method for showing the same thing, first observed by Orme in 1740. A straight glass tube, 50 or 60^{cm} in length and one or two in diameter, is placed transversely before the fire, supported horizontally near its two ends on rods of hard wood of about the same diameter, carefully leveled. It will now roll *toward* the fire. If the supporting rods be transferred inward so as to support the tube near its middle, the tube will gradually roll *from* the fire. In this case the expansion of the glass by the heat is the moving cause, the falling of the side thus made convex producing the motion.—(*Phil. Mag.*, June, 1880; *Nature*, xxii, 157, 318, 1880.)

Villari has experimented to determine the law of the production of heat by the electric spark in gases. He used a glass globe of about a liter capacity, having two horizontal and two vertical tubulures. By the former, the electrodes entered the globe; the upper vertical one carried a stopcock, and the lower a tube plunged in a diluted glycerin, serving as a thermometer. Care was taken to protect the globe from loss or gain of heat. The results are given in three laws: 1st, the heat developed by the electric spark in gases is directly proportional to the quantity of electricity which produces it; 2d, the quantity of heat developed by the electric spark increases in the proportion of its length; 3d, the heat and also the galvanometric deviations produced by the discharge of a condenser are independent of its surface. The result was not affected by the direction of the spark.—(*J. Phys.*, ix, 5, January, 1880.)

Barrett has studied the phenomena presented by the Trevelyan rocker, and has come to the conclusion that the theory which ascribes the motion to the rapid expansion and contraction of the metals in contact is not the correct one. He believes this motion to be due to the action of a polarized layer of gas between the hot and cold surfaces, like that existing between the hot and cold surfaces of the layer of vapor supporting a drop of liquid in the spheroidal state, termed by Stoney a "Crookes layer."—(*Nature*, xxi, 426, March, 1880.)

Carnelley, from certain of his experiments, concluded that in order to convert a solid into a liquid, the pressure must be above a certain point, which he calls the "critical pressure" of the substance, otherwise no amount of heat will melt the substance; just as in converting a gas into a liquid the temperature must be below the critical temperature, or no amount of pressure will liquefy the gas. As a deduction from his law, it follows that, provided the pressure be below the critical pressure, solid ice may be heated to temperatures far above its melting point, passing then directly into the gaseous condition without previously liquefying. He therefore tried the experiment, and he succeeded in obtaining "solid ice at temperatures so high that it was impossible to touch it without burning one's self." Not only so, but water has been frozen in a glass vessel which was so hot that it could not be touched by the hand without burning it. Ice has been maintained for some time at temperatures far above the boiling point of water, and then it sublimed away without previous melting. The pressure necessary was found to be anything below 4.6^{mm} of mercury, the tension of aqueous vapor at 0° C. In the case of mercuric chloride, these phenomena may readily be produced, since the critical pressure for this substance is only 420^{mm}. In commenting on these results, LeConte has called attention to their agreement with well-known facts. Of course it is understood that it is the vessel which is hot, not the ice; and that the temperature of the ice must be preserved at 0° by the rapid evaporation of it in the solid state. In this sense, the phenomena are comparable to those of Boutigny on the spheroidal state, and of Faraday on freezing mercury in a red-hot crucible. Substances are known which sublime without melting. Such bodies have their boiling points below their fusing points. By subjecting them to pressure, their boiling points may be raised above their fusing points. Thus metallic arsenic, which sublimes without fusing at 180°, melts under pressure below a red heat. The rapid evaporation prevents the body from reaching the fusing temperature. Conversely, by diminishing the pressure its boiling point is lowered below that of fusion. He gives a noteworthy quotation from Regnault, published in 1865: "It is evident that a volatile solid body may be always subjected to so slight a pressure that it will boil at a temperature inferior to that at which it melts. Thus ice at the temperature of —1° C. possesses an elastic force represented by 4.27^{mm}; in other words, it boils at a temperature of —1° C. under a pressure of 4.27^{mm}. Ice may therefore be entirely volatilized by ebullition under this feeble pressure without reaching its point of fusion, which is 0° C."—(*Nature*, xxii, 434, 603, September, October, 1880.)

Thomson has communicated to the British Association a method for determining the critical temperature for any liquid and its vapor without mechanism. The pure liquid is placed in a glass tube about 60^{cm} long, about 3 or 4^{cm} of the upper portion being occupied by the vapor. The tube is then hermetically sealed and placed in a vertical position. The upper part is then warmed until the surface of separation of liquid and vapor sinks below 5^{cm} from the top. Then warm the lower part containing the liquid till the surface rises again to a convenient position. Operate thus, keeping the surface of separation at as nearly as possible a constant position of 3^{cm} from the top of the tube until the surface of separation disappears. The temperature of the tube at the place where the surface of separation was seen immediately before disappearance is the critical temperature.—(*Nature*, xxiii, 87, November, 1880.)

Von Burg has presented a paper to the Vienna Academy on the action of safety-valves on boilers. He shows among other things that the authoritative directions given in different countries as to the size of safety-valves are not at all adequate, being based on erroneous conceptions. As to the cause of the small amount of the lifting of the valve during escape of steam (seldom over $\frac{1}{2}^{mm}$), a vibratory motion of this valve was at first supposed by the author; but further study and experiment led him to the hypothesis that the steam jets in lifting the valve do not begin to move from its middle point but from the periphery of a circle ρ out to the circumference of the valve of radius r; so that the pressure of steam on the under surface of the valve is composed of two parts, of which the inner or aërostatic is produced by the solid steam cylinder of radius ρ and the outer or weak aërodynamic part by the external hollow cylinder of $r—\rho$ thickness of wall. The phases of development of steam tension were also investigated.—(*Nature*, xxi, 189, December, 1879.)

Aitken has propounded the rather remarkable theory that dust is the germ of which fogs and clouds are the developed phenomena. Steam was mixed with air in two large glass receivers, one of which contained filtered the other unfiltered air. In the former the steam condensed in its well-known cloudy form, while in the filtered air no cloudiness whatever appeared. From these and similar experiments the author concludes: 1st, that whenever water vapor condenses in the atmosphere it always does so on some solid nucleus; 2d, that dust-particles in the air form the nuclei on which the vapor condenses; 3d, that if there was no dust there would be no fogs, no clouds, no mists, and probably no rain, and that the supersaturated air would convert every object on the surface of the earth into a condenser on which it would deposit; and 4th, that our breath when it becomes visible on a cold morning, and every puff of steam as it escapes into the air, show the impure and dusty condition of our atmosphere. The importance of these results, meteorologically, is very great.—(*Nature*, xxiii, 195, December, 1880.)

2. *Conduction and Radiation.*

Weber has made a series of experiments upon the conductibility of liquids for heat, resting in principle upon Fourier's theory. Suppose a thin liquid layer bounded by two parallel metallic plates, the whole possessing a uniform temperature. At a given instant the lower plate is cooled to 0° and the whole system is inclosed in a space at 0°. By determining the law of the variation of the temperature at the center of the upper plate, the coefficient of conduction may be calculated. The experiment was made as follows: Upon a plate of copper 0.05^{m} in thickness, three small slips of glass 2 to 3^{mm} thick were placed to support the second plate of copper. This plate was perforated at center by a small hole through which the liquid was introduced until it formed a slightly convex meniscus at the edges of the plates, care being taken to leave no bubble of air. When the whole had acquired the temperature of the laboratory one of the junctions of a thermo-electric couple was put in contact with the center of the upper plate, the other remaining in the melting ice. An aperiodic oscillation galvanometer in the circuit gave, by a simple reading, the electromotive force, and so the temperature of the upper plate. By the help of a pulley and cord, the two plates thus prepared were placed on a thick and flat plate of ice and immediately covered with a double cylinder filled with ice. The lower plate takes at once the temperature of the ice and remains so; in one or two minutes the circuit of the galvanometer is closed and the position of the needle read every 20 seconds. The value of k, in absolute C. G. S. units, was found for carbon disulphide, 0.0250; for benzene, 0.0200; for water, 0.0745; copper sulphate, 0.0710; for zinc sulphate, 0.0691 to 0.0711; salt, 0.0692; alcohol, 0.0292; ether, 0.0243; chloroform, 0.0220; oil lemon, 0.0210; olive oil, 0.0235; glycerin, 0.0402. These results in general agree with those obtained by Lundquist.—(*J. Phys.*, ix, 169, May, 1880.)

Crova has proposed a purely optical method for measuring high temperatures, founded upon the principle that two incandescent bodies, having the same radiating power, are at the same temperature when the spectra which they give are identical in extent. The instrument which he has devised for these measurements he calls a spectropyrometer. It is composed of a direct-vision spectroscope, having a slit in the eye-piece to limit the field, and having the observing telescope movable about an axis perpendicular to the length of the spectrum, its play being limited to wave-length 676, and on the other side to wave-length 523. Over half the slit is a total-reflection prism, and in front of the slit is a Nicol prism in the center of a graduated circle, a second Nicol being placed either between this and the lamp, or preferably just behind the slit of the collimator. To measure the temperature of a body in optical degrees the telescope is first directed to the fixed point in the red, the two Nicols are put at 0°, and the intensities of the two spectra made equal, either by moving the moderator-lamp used as the standard farther off, or by rotating a Nicol placed between the body and the reflecting prism. The telescope is then moved to wave-length 523 in the green, and two green images are obtained of unequal intensities. If the temperature of the body is less than that of the lamp (below 2000° C.) the greens are made equal by rotating the Nicol. If a be the angle of rotation the intensity is equal to $1000 \cos {}^2 a$ if the temperature of the lamp is 1000 optical degrees. To calibrate the instrument, the temperature of the lamp flame was compared with that of an air-thermometer with a porcelain bulb heated in a furnace until the spectra of the two were identical throughout. In this way Crova finds in optical degrees the following values for the sources examined: Platinum strip heated to redness in a gas flame, 524; the same heated to a white heat in a gas blow-pipe flame, 810; moderator-lamp fed with colza oil, 1000; stearin candle, 1162; illuminating gas (Argand burner), 1373; oxyhydrogen light (oxygen and coal gas on lime), 1806; electric light (60 Bunsen cells), 3060; solar light, 4049. The author hopes to compare in this way the intensities of the simple radiations of incandescent vapors, provided that the spectrum consists of more than a single line.—(*Ann. Chim. Phys.*, V, xix, 472, April, 1880.)

Mouton, in an elaborate memoir, has given the results of his experiments to determine the wave-length of dark heat rays by a method depending on the position of interference bands in polarized light. In the formula the wave-length appears as a function of the thickness of the interfering film, of the difference of the indices for the two rays of this wave length, and of the number of wave-lengths concerned. By the measurement of these values the wave-length was easily calculated. The result obtained is noteworthy, since it gives us a wave-length actually measured of 0.002140^{mm}, or 2.14 μ. If this be compared with the wave-length of the ultra-violet line R, measured by Mascart, 0.00031775, it will be seen that the wave-length of this ultra-red line is more than six and a half times greater. The entire ether gamut known is more than two and a quarter octaves, while the total chemical and luminous radiation covers scarcely a single one.—(*Ann. Chim. Phys.*, V, xviii, 145, 1879; *J. Phys.*, viii, 393, December, 1879; ix, 113, April, 1880.)

Rosetti has given a series of measurements upon the temperature of the voltaic arc, using a method which consists in receiving upon the face of a thermopile placed at a convenient distance, rays emitted from a surface of known area, and measuring the thermic effect on a sensitive galvanometer. The following are his conclusions: 1st. The carbon positive pole from the moment of the production of the electric light has always a higher temperature than the negative. 2d. These temperatures vary according to the variation in the strength of the current. 3d. They are as much higher as the radiating surface is smaller, provided, obviously, that the end of the point be included. 4th. For the negative pole the minimum temperature was found to be 1910° C., the radiating surface being large and not very brilliant in some places. The maximum temperature observed was 2532° C., the radiating surface being one-half the preceding. 5th. For the positive pole the minimum temperature found was 2312° C., the carbon being very large and the radiating surface extended. For the maximum temperature, 3200° C., where the carbon was thin and the radiating surface nearly one-fourth of that corresponding to the minimum temperature. 6th. The extreme point of the negative carbon may be considered at 2500° C. at least; that of the positive carbon not less than 3200°.—(*Ann. Chim. Phys.*, V, xviii, 457, December, 1879; *J. Phys.*, viii, 257, August, 1879.)

Rosetti has published also an extended memoir on the temperature of the sun, giving the experimental methods employed and the results obtained. For the purpose of determining the law of radiation as a function of the temperature, the thermopile, which was connected with a Wiedemann reflection galvanometer, received the heat radiated from a Leslie cube, containing water for the lower and mercury for the higher temperatures, up to 300° C. Accurate thermometers gave the temperatures of the air outside and of the liquid inside the cube. From the data thus obtained an empirical formula was derived, which the author thinks represents the facts better than that of Dulong and Petit. From this, results were calculated for temperatures beyond 300° and up to 2000°, which agreed well with those derived from experiment. The apparatus was then applied to the determination of the solar temperature. The thermopile was placed where the direct rays of the sun could fall normally upon its face. Four readings of the galvanometer were made during each observation: the first with open circuit to fix the zero point; the second, with closed circuit, the case of the pile being closed; the third, after opening the case to allow the heat rays to act; the fourth, with the case open and the solar rays intercepted by a double-walled screen placed one meter off. This last reading was generally negative, the pile radiating heat into space. Calculated from these results it appeared that the thermic effect which would be produced by the solar radiation falling normally on the face of the pile, if the atmosphere did not exist, or if the pile were above it, is represented by 323 scale divisions. Since resistance was used in the circuit in the last experiments, this value must be multiplied by 5.6921 to make it comparable to the others; this gives 1838.5 divisions. Calling the effective temperature of the sun, that which an incandescent body of the same size placed at the same distance should have to produce the same effect, its emissive power being at the maximum, the formula gives as the absolute effective temperature of the sun 10238°.4, or in degrees centigrade, 9965.4. The author concludes that if the absorption of our atmosphere only be taken into the account, the true temperature of the sun cannot be far inferior to ten thousand degrees. If the absorption produced by the solar atmosphere be also considered, and Secchi's estimate of .88 be allowed for it, then this temperature is higher but not very far superior to twenty thousand degrees.—(*Ann. Chim. Phys.*, V, xvi, 177, June, 1879.)

Langley has compared the intensity of the solar-heat radiation with that of the incandescent surface of Bessemer steel in fusion as it flows from the converter. The temperature of this molten metal is above that at which platinum melts, a wire of this metal fusing in the gas stream issuing from the mouth of the converting vessel; hence it is from 1800° to 2000° C. The heat radiated from the liquid stream fell on one face of a thermopile, while a bundle of solar rays was reflected on to the other face. Though the apparant diameter of the opening of the converter was many times that of the sun, so much greater was the energy of the latter that a lens was interposed to form a magnified image of the sun on the pile, and it was diaphragmed to bring the needle to zero. Calculating for equal diameters, the solar energy was found to be 86 times that of the molten metal at least. Photometric comparison showed the solar-light radiation to be 5,300 times that of the metal. Crova, in noting these experiments, calls attention to the rapid increase of light emitted by melted silver as the temperature rises, being 147 times greater at 1200° than at 916°, and hence 28,900 times at 1500°, as evidence that the sun's temperature is quite moderate compared with some of the calculations made on the subject.—(*J. Phys.*, ix, 59, February, 1880.)

Crookes has made remarkable progress in studying the phenomena of molecular physics in high vacua, and has obtained results even more novel and striking than those connected with his marvelous little instrument, the radiometer. In a paper read to the Royal Society December 5, 1878, he showed that the dark space which surrounds the negative pole in an ordinary vacuum tube illuminated by an induction coil, is the result of intense molecular vibration which excites a molecular disturbance in the surface of the disk and the surrounding gas. As the rarefaction increases, this layer of molecular disturbance increases in thickness. At a pressure of 0.078^{mm}, it extends for 8^{mm} from the disk. It is greatest in hydrogen and least in carbon dioxide. Numerous experiments were devised to ascertain whether this visible layer of molecular disturbance was identical with the invisible layer of molecular pressure. A radiometer with aluminum disks, each coated with mica, when made the negative electrode, revolved rapidly as soon as the dark space is made by exhaustion to extend to the glass. With a cup-shaped aluminum electrode, the convergence of the lines of force to a focus was very marked. When the exhaustion becomes very high the dark space fills the tube, and where the rays after divergence fall on the glass, a sharply-defined spot of greenish-yellow light appears. This greenish-yellow phosphorescence of molecular impact is due to the particular kind of glass used. Other kinds of glass give different colors. At 4 M exhaustion (M refers to millionths of an atmosphere) no other light than this is seen. At 0.9 M the phosphorescence reaches it maximum. At 0.15 M the spark passes with difficulty and the light appears in flashes. At 0.06 M the vacuum is non-conducting, and only very intense sparks will pass. Beyond this nothing has been observed. The rays producing the green phosphorescence will not turn a corner. Hence a body in their path intercepts them and casts, as it were, a shadow on the glass behind it.

Mr. Crookes advances the theory, therefore, that the induction spark actually illuminates the lines of molecular pressure caused by the electrical excitement of the negative pole. The thickness of the dark space is the measure of the mean length of the path between successive collisions of the molecules. The extra velocity with which the molecules rebound from the excited negative pole keeps back the more slowly moving molecules which are advancing toward that pole. The conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the collisions. By using a rotating fly it may be caused to revolve with high velocity by directing the molecular impact on one side of it. Moreover, these lines of molecular force are markedly deflected by a magnet, the action being to twist the trajectory of the molecules, the direction of twist when an electro-magnet is used being that of the electric current round the magnet. When the magnet is so adjusted as to exert a uniform downward pull on the molecules, the trajectory is much curved at low exhaustions, and gets flatter as the rarefication increases, exhibiting a close parallelism with the phenomena of projectiles. Moreover, great heat is produced by the impact of these molecules. A large hemispherical cup of aluminum used as the negative pole gives a focus in which platinum may be melted. The conditions in these high vacua are special. The free path of the molecules is so long that the average molecule is allowed to obey its own motions or laws without interference; so that if this path is comparable to the dimensions of the vessel, the properties which constitute gaseity are reduced to a minimum, and the matter becomes exalted to an ultra gaseous state. The phenomena in these tubes reveal a new world, a world where matter exists in a fourth state, where the corpuscular theory of light holds good, and where light does not always move in a straight line.

In a lecture on radiant matter, delivered at the Sheffield meeting of the British Association, August 22, 1879, Crookes discussed and elegantly illustrated the principles given in the paper above quoted. His vacua are thus graphically described: "According to the best authorities a bulb of the size of the one before you (13.5^{cm} in diameter) contains more than 1,000,000,000,000,000,000,000 (a quadrillion) of molecules. Now, when exhausted to the millionth of an atmosphere, we shall still have a trillion molecules left in the bulb, a number quite sufficient to justify me in speaking of the residue as *matter*. To suggest some idea of this vast number, I take the exhausted bulb and perforate it by a spark from the induction coil. The spark produces a hole of microscopical fineness, yet sufficient to allow molecules to penetrate and to destroy the vacuum. The inrush of air impinges against the vanes and sets them rotating after the manner of a wind-mill. Let us suppose the molecules to be of such a size that at every second of time a hundred millions could enter. How long, think you, would it take for this small vessel to get full of air? An hour, a day, a year, a century? Nay, almost an eternity! A time so enormous that imagination itself cannot grasp the reality. Supposing this exhausted glass bulb, indued with indestructibility, had been pierced at the birth of the solar system; supposing it to have been present when the earth was without form and void; supposing it to have borne witness to all the stupendous changes evolved during the full cycles of geologic time—to have seen the first living creature appear, and the last man disappear; supposing it to survive until the fulfillment of the mathematician's prediction that the sun, the source of energy, four million centuries from its formation, will ultimately become a burnt-out cinder; supposing all this—at the rate of filling I have just described (100 million molecules a second) this little bulb even then would scarcely have admitted its full quadrillion of molecules. But what will you say if I tell you that all these molecules, this quadrillion of molecules, will enter through the microscopic hole before you leave this room? The hole being unaltered in size, the number of molecules undiminished, this apparent paradox can only be explained by again supposing the size of the molecules to be diminished almost infinitely, so that instead of entering at the rate of 100 millions every second they troop in at the rate of something like 300 trillions a second. I have done the sum, but figures, when they mount so high, cease to have any meaning, and such calculations are as futile as trying to count the drops in the ocean."—(*Proc. Roy. Soc.*, December 5, 1878; *Phil. Mag.*, January, 1879; *Am. J. Sci.*, III, xvii, 218, March, 1879; xviii, 241, October, 1879; *Nature*, xx, 228, 250, 419, 436, 1879.)

In a subsequent communication to the Royal Society, Crookes says that he has examined some of these phenomena more closely, and has confirmed the molecular-stream hypothesis. If, however, the residual molecules, being negatively charged by contact with the negative pole, and so repelled, were solely acted on by the initial impulse from the negative pole, they would take a direction accurately normal to the surface repelling them, and would start with their full velocity. But the molecules, being all negatively electrified, exert mutual repulsion, and therefore diverge laterally. The negative pole, likewise, not only gives an initial impulse to the molecules, but it also continues to act on them by repulsion, the result being that they move with an accelerating velocity the further they get from the pole. Within the dark space at a moderate exhaustion, the velocity does not accumulate to a sufficient extent to produce phosphorescence; but at higher exhaustions the mean free path is long enough to allow the molecules to get up speed sufficient to cause phosphorescence. The luminous boundary to the dark space around the negative pole is probably due to the impact of molecule against molecule, producing phosphorescence of the gas in the same way as the impact of molecules against German glass produces phosphorescence of the glass. The effect of deadening produced on glass by long-continued phosphorescence, which was illustrated by stenciling, by means of a discharge from the negative pole, the image of a maltese cross on the end of a large pear-shaped bulb, has been further developed by opening the bulb and heating the wide end in the blowpipe flame until soft and melted out of .shape. It was then blown out again into its original shape and re-exhausted; on connecting it with the coil, the original ghost of the cross was seen to be still there. At Maxwell's suggestion a third, idle, electrode was introduced into a tube. On connecting it with an electroscope, it appeared that when in a direct line between the positive and negative poles, and receiving the full impact of the molecules driven from the negative pole, it had a strong positive charge. The effect of magnetism on the discharge has been further examined, and this was found to be so sensitive that when the tube was placed parallel to the earth's equator, the earth's magnetism was sufficient to cause the spot of light to move five millimeters away from the position it occupied when the tube was parallel to the dipping needle. Complete and orderly rotation of the molecular rays was obtained by placing an electro-magnet beneath the tube in a line with the terminals. With reference to the heating effect of molecular bombardment, a plate of German glass was held in the focus and soon became red hot. Gas then appeared in the tube, which gave the hydrogen spectrum. This was pumped out and the experiment repeated. The glass could be heated to dull redness without evolution of gas, but when the heat approached the fusing point, the lines appeared. This hydrogen the author thinks comes from vapor of water which is obstinately held in the superficial pores, and which is not entirely driven off by anything short of actual fusion of the glass. From an experiment in which a hole in a mica disk was placed in front of a negative electrode of platinum, and the tube opposite the hole was not more darkened than the surrounding portions, Crookes infers that the molecular stream does not consist of particles of the negative pole shot off from it. With regard to the production of phosphorescence by impact in crystals, the conclusion is arrived at that the rays whose direction of vibration corresponds to the direction of maximum optical elasticity in the crystal are always originated where any light is given out.—(*Nature*, xxii, 101, 125, June, 1880.)

More recently, Crookes has written a letter to the secretary of the Royal Society, in answer to a challenge from De la Rue, defining his position in reference to the ultra-gaseous or fourth state of matter. This letter concludes thus: "The molecule—intangible, invisible, and hard to be conceived—is the only true *matter*, and that which we call matter is nothing more than the effect upon our senses of the movements of molecules, or, as John Stuart Mill expresses it, 'a permanent possibility of sensation.' The space covered by the motion of molecules has no more right to be called matter than the air traversed by a rifle bullet can be called lead. From this point of view, then, matter is but a mode of motion; at the absolute zero of temperature the inter-molecular movement would stop, and although *something* retaining the properties of inertia and weight would remain, *matter*, as we know it, would cease to exist."—(*Proc. Roy. Soc.*, June, 1880; *Nature*, xxii, 153, June, 1880.)

Marangoni has studied the diathermanous power of liquid films, using for this purpose soapy water. A series of equidistant films 8 or 10 in number was produced in a wide glass tube, and heat rays from a smoked plate at 400° were reflected through the tube by a mirror, a second mirror at the other end directing them on the face of the thermopile. He found, (1) that the first film absorbs more than half the heat, reducing the deflections from 38 to 18 divisions; (2) the successive films produce decrements as theory indicates; (3) the diminution of intensity depends very little on reflection, but almost wholly on absorption; (4) the thinner the film the more diathermanous it becomes; (5) the diathermaneity is not sensibly affected by mixing various salts with the solution of soap.—(*Nature*, xxi, 620, April, 1880.)

Lecher has made further experiments on the absorbing action of carbon dioxide for radiant heat, with especial reference to the effect of this gas in the atmosphere. Using a gas flame and a glass cylinder, he found that a layer of the gas 214^{mm} thick allowed 94.8 per cent. of the radiation to pass; 536^{mm} allowed 93.8 per cent.; and 917^{mm} 89 per cent. The sun's rays were proved to undergo considerable weakening in their passage through carbon dioxide; a layer of the gas one meter thick absorbing 13 per cent. when the sun's altitude was 59°, diminishing as the sun got lower. The absorption of solar radiation by carbon dioxide is selective therefore, the absorbable wave-lengths becoming rarer as the thickness of the atmosphere already traversed increases. From his experiments, Lecher calculates the proportion of carbon dioxide in the atmosphere to be 3.27 parts in 10,000 by volume. The agreement of this value with that obtained by direct chemical methods suggests that absorption is a good method for its rapid determination in the air.—(*Nature*, xxiii, 209, December, 1880.)

3. *Specific heat.*

Mlle. Stamo has published as an inaugural dissertation at Zurich some researches upon the specific heat of water. In the first set of experiments a brass calorimeter was used, filled to within one centimeter of the top with copper turnings loosely packed. Into this the water, heated gradually in a copper vessel placed in an oil bath, was poured. The high conducting power of the copper turnings rendered it unnecessary to agitate the liquid. The author having determined in advance, as exactly as possible, the specific heat of copper as compared with water at ordinary temperatures, the comparison could easily be made with the water heated to 60° or 80°. The mean of the coefficient of variation of the specific heat of water is 0.0012550. In the second set of experiments, the same electric current was passed through wires of platinum, or of German silver, about 3^{mm} long, rolled on rubber frames and immersed in calorimeters full of water, one being surrounded with ice, and the other with water at a constant temperature t. From the heating observed, the specific heats at 0° and at t° were calculated. In this way the variation coefficient was found to be 0.000859, a value of the same order as in the first case.—(*J. Phys.*, ix, 138, April, 1880.)

Witz has examined the cooling power of air at high pressures with a view to verify the exactitude of the law of Dulong and Petit, according to which the heat removed at each instant from a body by any gas surrounding it depends only upon the excess of temperature of the body above the surrounding medium, and upon the pressure of the gas. The apparatus consisted of a cast-iron cylinder of 13 liters capacity, strong enough to sustain a pressure of 10 atmospheres, lampblacked on its interior. Within this was placed a cylindrical cup of thin iron, 54^{mm} long and 27^{mm} in diameter, surmounted by a tube 8^{mm} diameter, by which it is adjusted to the center of the large cylinder. The cup holds 200 grams of mercury, and the stem of a thermometer is plunged into it. The volume of the outer cylinder is 400 times that of the inner. In making an experiment the 200 grams of mercury, weighed with care, is heated in an iron vessel, and poured into the central cup. The thermometer is at once immersed in it, and its temperature noted by means of a telescope a meter distant. The time of passage of the column from five to five, or from ten to ten divisions is noted on a chronograph. The pressures experimented with were from 760 to 6,400^{mm}; and the general result obtained was that the law of Dulong and Petit ceased to be applicable at about 1,520^{mm}, the pressure exponent passing from 0.45 to 0.65; though at 3,040^{mm} it was 0.54, and at 6,080^{mm}, 0.44. Studying the phenomena more carefully between 800 and 2,000^{mm}, Witz found that Dulong's law represented the facts from 800 to 1,200^{mm}; and that from 1,200 to 1,600^{mm} there was a very rapid change, the exponent rising to 0.85, the curve of velocities presenting a point of inflection near this pressure. This the author shows in a graphic curve.—(*Ann. Chim. Phys.*, V, xviii, 208, October, 1879.)

LIGHT.

1. *Reflection and Refraction.*

Schwendler has proposed a new light-unit founded upon the ignition of a strip of platinum, as originally suggested in 1844 by Draper and in 1859 by Zöllner, and put into practical use for electrical illumination by Farmer also in 1859. This unit of luminous intensity is given by a current of 6.15 webers passing through a platinum strip 2^{mm} wide, 36.28^{mm} long, and 0.017^{mm} thick, weighing 0.0264 gram, having a calculated resistance of 0.109 mercury-unit, and an actual resistance (including that at the two contacts) of 0.143 mercury-unit at the temperature of 66° F. This strip should be of pure metal, cut into the U-form, and connected by large conductors with eight Grove cells of low resistance. The current is maintained constant by means of a mercury rheostat, in the form of a U-shaped groove, a millimeter in cross-section and a meter long, cut in a board and filled with mercury. A copper bridge movable along this groove enables the current to be kept constant, as indicated on a galvanometer. The P. L. S. (platinum light standard) is equal to nearly 0.7 standard candle. The economy of this light in comparison with that of the voltaic arc is over 70 times in favor of the arc.—(*Phil. Mag.*, V, viii, 392, November, 1879; *J. Phys.*, ix, 135, April, 1880.)

Eder has suggested a chemical photometer. The solutions are prepared by dissolving separately, each in one liter of water, 40 grams of ammonium oxalate and 50 grams of mercuric chloride (corrosive sublimate). When used, two volumes of the former solution are mixed with one volume of the latter, and exposed to the light. The liquid becomes turbid, and a black precipitate is thrown down. The weight of this precipitate per square centimeter of surface exposed to the light gives the measure of its intensity.—(*Ber. Ak. Wien*, 1879, 240; *J. Phys.*, ix, 110, March, 1880.)

Gouy has investigated the photometry of colored flames, and has devised a spectroscope by which various sources of light of different colors may be compared with others, the comparison being made in parts of their spectra having the same tints. The spectroscope is an ordinary two-prism instrument, the collimator having its objective half covered with a plate of plane glass so inclined that the light from a second collimator falling on its face is reflected into the prisms. The eye, therefore, sees in the observing telescope two spectra in exact coincidence, one coming from each of the two collimators. One of these comes from a gas flame, and is continuous; the other is a bright line spectrum coming from an incandescent vapor. By means of two Nicol prisms the intensity of the former may be regulated. The angle between these prisms measures the illuminating power. The author shows that for wide bands, and for continuous spectra, their transparence is complete. For narrow lines, it appears not to be true; that for each simple ray the emissive and the absorptive power depend only on the quantity of vapor contained in a right cylinder having a unit base, and for its height the thickness of the layer; that two layers of vapor at the same temperature, which give the same brilliance to a given line, have identically the same vapor quantity and are optically alike; and that the widening of lines is a necessary consequence of the fact that the radiation of the vapor is a continuous function of the wave-length, which does not disappear beyond the lines, but forms a background of continuous spectrum, which is never wanting when the illumination is sufficiently brilliant.—(*Ann. Chim. Phys.*, V, xviii, 5, September, 1879; *J. Phys.*, ix, 19, January, 1880.)

Michelson read at the Saratoga meeting of the American Association a paper describing his experimental determination of the velocity of light. The method which he employed was Foucault's, with a revolving mirror, but in which some modifications were introduced. The chief of these was the replacement of Foucault's spherical mirror by a plane mirror, thus enabling the distance between this mirror and the revolving mirror to be increased indefinitely. To make the displacement of the returned image as great as possible, the distance from the slit to the revolving mirror and the speed of rotation should also be increased. But increasing the first distance diminishes the second, from the laws of conjugate foci. This difficulty was overcome by using a lens of 150 feet focus, and by placing the revolving mirror 15 feet within the principal focus of the lens. In the experiments the distance between the two mirrors was nearly 2,000 feet, and the distance from the slit to the revolving mirror was about 30 feet, the speed of the rotating mirror being about 257 revolutions per second. The deflection obtained exceeded 133^{mm}, being about 200 times that obtained by Foucault. This deflection was measured to within three or four hundredths of a millimeter, and the result therefore may be regarded as correct within one ten-thousandth part. The mirror was rotated by an air turbine on the same axle, the pressure of air being kept constant by means of a water-gauge. An electrically vibrated tuning-fork was used to regulate and measure the speed, the light from the revolving mirror being reflected from a steel mirror on one of the prongs to a piece of plane glass in front of the eye-piece, and thence to the eye. When the mirror makes as many turns as the fork makes vibrations, or when these are in simple ratio to each other, the two images become stationary. The electric fork made 128 vibrations, and was compared at each set of observations with a standard Ut_3 fork making 256.072 vibrations at 65° F. The deflection was measured with an accurate micrometer. The results are given in 100 readings, each of which is the mean of ten separate observations. The mean value corrected for temperature, for the velocity of light in air is 299,864 kilometers per second. Adding 80 kilometers to reduce it to vacuo, this value becomes 299,944 kilometers, with a probable error of ±51 kilometers.—This gives 186,380 miles per second reduced to English measure.—(*Am. J. Sci.*, III, xviii, 390, November, 1879.)

Ayrton has given a lecture at the Royal Institution upon magic mirrors, the effects of which, as it appears, so far from being intended, were quite unknown to the Japanese, though known to the Chinese from the earliest times. On reflecting a divergent beam of light from such a mirror, Ayrton found that the pattern on the back appeared bright on a dark ground; with a parallel beam no pattern could be seen; while with a convergent beam the pattern was dark on a light ground. Hence, the effect must be caused by inequalities in the curvature of the reflecting surface corresponding to the raised pattern on the back, the portions where the relief increases the thickness of the plate being flatter than the remaining convex surface, and sometimes actually concave. The result is very exceptional, being shown well in only 2 or 3 per cent. of the mirrors made. It is produced when the bronze casting is worked sufficiently thin to determine a buckling of the metal.—(*Nature*, xix, 186, 539, December, 1878; April, 1879.)

Govi presented to the Turin Academy in 1864 a valuable historical paper upon the magic mirrors of the Chinese, called by them *Theon-kouang-kim*, or mirrors which the light can penetrate. In this he shows that if the mirror be heated from behind the thin portions heat most rapidly, become more convex, and the magic effect is made more marked. Bertin, associating himself with Duboscq, sought to improve upon this suggestion of Govi's, by varying the curvature by pressure. A frame was constructed for holding the mirror so that air could be forced in behind it to make its surface more convex, or exhausted to make it concave. A mirror in nickel-plated brass, on the back of which figures were engraved and relief ornaments soldered, became very magic by pressure, giving simultaneously a dark image of the depressed designs and light images of those in relief.—(*Ann. Chim. Phys.*, V. xx, 99, 110, 143, May, 1880; *J. Phys.*, ix, 401, December, 1880.)

Bibart has shown that although the images produced in the kaleidoscope are sharp when looked at directly, whatever be the angle between the mirrors, this is true of projected images only when the angle between the mirrors is an even submultiple of the circumference. For this projection the light should be concentrated upon the object, say a small hole in a blackened screen. Behind this screen are the blackened mirrors, one horizontal, and behind these a lens for producing the image on the screen. If the inclination of the second mirror be varied, the number of the images increases by doubling one of them.—(*J.Phys.*, ix, 11, January, 1880.)

Bleekrode has measured the indices of refraction of cyanogen, carbon dioxide, and ammonia, liquefied in a Faraday tube having parallel sides at one end. He used the method of determining the index by the displacement of an object seen with a microscopic objective when the space at first empty is filled with the liquefied gas. The index of cyanogen, at 13°, for the sodium line, was found to be 1.320; of carbon dioxide at 19°, 1.163; of ammonia at 17°.5, in sunlight, 1.314. The index of zinc-ethyl was obtained as 1.489. The above value for CO_2 is very near that obtained by Brewster in 1826, for a liquid contained in a cavity in Brazilian topaz, undoubtedly liquid CO_2.—(*Ann. Phys. Chem.*, II, viii, 400, 1879; *J. Phys.*, ix, 141, April, 1880.)

Bertin has described an inverting prism devised by Duboscq for use with the lantern, in cases where the object cannot itself be inverted. It consists of a right-angled isosceles prism whose hypothenuse is placed parallel to the axis of a convergent beam of light, its center coinciding with the focal point. Under these circumstances the beam is totally reflected from the base of the prism and inverted. In practice, two of these prisms are placed in the beam from the lantern, with their bases together. The use of a prism for this purpose is not new; it is figured in Brewster's Optics (London, 1853, p. 454,) where it is described for the same purpose. More recently (*J. Fr. Inst.*, lxiii, 375, 1872) Zentmayer has constructed an inverting prism for the microscope, which he has also used for the lantern, and which would seem to be more effective so far as amount of light is concerned than the Duboscq arrangement.—(*J. Phys.*, viii, 336, October, 1879.)

Gariel has proposed some ingenious mechanical models for illustrating the relations of the foci of lenses. Two rods are articulated on a line perpendicular to the axis of the lens—drawn in section—at a point near its circumference. These rods are attached near their ends to opposite parts of a cord which moves over pulleys attached to the frame. Since the angle between the rods remains constant, by moving the cord the variations in the positions of intersection of the rods with the axis, *i. e.*, the foci, may be clearly shown. A noteworthy modification of this model enables the optical phenomena of the eye, accommodation, emmetropia, myopia, and hypermetropia, to be shown distinctly to an entire class.—(*J. Phys.*, ix, 340, October, 1880.)

Stevenson has suggested an instrument for exploring dark cavities which are inaccessible to direct light. It is simply a train of prisms by which the ray is properly bent, these prisms being suitably achromatized. Light is thrown into them from a mirror at the end of the train. This traverses the system, illuminates the object by reflection from the last surface, also a mirror, and then returns over the same path, passing to the eye through an opening in the first mirror. The number of prisms which may be used is limited only by the light and the definition.—(*Nature*, xxi, 14, November, 1879.)

Joseph Le Conte has continued his researches on binocular vision, and has published a paper on the laws of ocular motion. The conclusion which he reaches is that when the eyes move in the same direction, parallel to each other, as in ordinary vision of objects, all their motions are governed by the law of Listing; *i. e.*, they are effected without rotation on the optic axes. But when, on the contrary, they move in opposite directions, as in strong convergence, then the law of Listing is entirely abrogated or overborne and another law reigns in its place.—(*Am. J. Sci.*, III, xx, 83, August, 1880.)

Steinhauser has pointed out a fixed relation between the size and relative position of the two views of a stereoscopic picture, the lenses of the camera with which it is taken, and the optical arrangements of the stereoscope in which it is to be viewed. If these relations are rightly observed the effect of relief will be much more perfectly attained for all parts of the picture. The eye-pieces of the stereoscope above the plane of the photographic pictures ought to be made as nearly as may be equal to the focal length of the objective of the photographer's camera, and this again should be about equal to the mean distance of easy vision, or from 10 to 12 inches. Hence he suggests: 1st, that all stereo-photographs should be taken with lenses of the same focal length, say 15^{cm}.; 2d, that all should be made of equal breadth or about 75^{mm}; and 3d, that the distance between the centers of the objective lenses should be constant.—(*Nature*, xxi, 117, December, 1879.)

Obach has made a series of experiments to determine whether the phosphorescent light of Balmain's paint would produce any sensible effect on the conductivity of selenium. For this purpose a Siemens selenium cell was used, which was exposed to a phosphorescent surface 20 by 30^{cm}, placed at 60^{cm} distance. When exposed to the light reflected from the ceiling of a semi-dark room, the light from the phosphorescent surface reduced the conductivity of the selenium 0.7 per cent.; light from the ceiling of a well-lighted room for 15 minutes, 2.4 per cent.; light of sky at 5 p. m. for several minutes, 4.6 per cent.; light from few inches magnesium ribbon, 5.1 per cent.; sunlight for two minutes, 7.8 per cent. The influence of 350 square centimeters of luminous surface, excited by diffused daylight, was found equal to 0.0014 standard candle or 0.04 standard candle per square meter.—(*Nature*, xxii, 496, September, 1880.)

Graham Bell presented to the American Association at its Boston meeting a paper by himself and Tainter on the production and reproduction of sound by light. The apparatus devised for the purpose he calls a photophone; and its action is based on the fact that when an intermittent beam of light is made to fall on a disk of almost any material, this disk emits sounds whose pitch is the same as the number of intermissions. The substance most sensitive, however, is selenium, which, as is well known, diminishes in its electrical conductivity by the action of light. When therefore an electric current was passed through a selenium cell and a telephone, the intermittent beam of light falling on the selenium varied its resistance so as to reproduce an intermittent electrical current of the same pitch distinctly audible in the telephone. The cell was made of disks of brass, alternating with slightly smaller disks of mica, the metal disks being alternately united electrically. In the grooves between these metal disks melted selenium was placed, and the whole was heated to such a temperature that the selenium passed into the crystalline state. This cell, placed in the focus of a parabolic mirror, constituted the receiver. The transmitter consisted simply of a sheet of mica or thin glass, silvered, against the back of which the voice could be directed by means of a mouth-piece. Upon this a beam of condensed sunlight was allowed to fall, whence it was reflected to the distant receiver. On talking into the mouth-piece, the beam of light varied correspondingly, and the spoken words became audible in the telephone.—(*Am. J. Sci.*, III, xx, 305, October, 1880. See also *Ann. Chim. Phys.*, V, xxi, 399, 560, 1880; *Nature*, xxii, 500; xxiii, 16, 58, 1880.)

Mercadier has studied the simpler forms of the photophone, which he calls radiophone, a sort of optical siren, in which a rotating disk pierced with holes is interposed in the path of light-rays, causing intermittences of a period corresponding to the speed. The disk used is simply a sheet of black paper gummed on a glass disk to avoid the whistling sound noticed with perforated disks. The receiving disks were fixed in a suitable holder, at the end of a short hearing-tube of India rubber. When the substance used was opaque, like zinc, copper, etc., the loudness is the same, whether polished or not. Thin disks are better than thick ones, and glass and quartz gave good results. A film of smoke or paint or of metallic silver on the front of the disk diminishes the effect, while blackening the back of the disk makes it louder.—(*Nature*, xxiii, 209, December, 1880.)

2. *Dispersion and Color.*

J. W. Draper has described a new form of spectrometer, intended for comparing the brilliancy of lights. It depends on the optical principle that a light is invisible in presence of another sixty-four times stronger. To produce it, the scale-tube is removed from the common three-tubed spectroscope, and a piece of glass ground on both sides is placed against the aperture. By placing a gas-flame in front of this glass, the field appears uniformly illuminated. This is the extinguishing light. Without it, the spectrum of a luminous flame placed before the slit appears as usual. With it, this spectrum appears in a field of light, the brilliancy of which can be varied at pleasure. When the extinguishing flame is distant, the whole spectrum is visible. As it comes nearer, the violet first disappears, and then the other colors in the order of their brightness. Though the yellow is commonly supposed to be the brightest of the rays, yet it disappears in this treatment in the order of its refrangibility, the red being plainly perceptible long after the yellow has gone. To render the extinguishing light more intense in order that it may obliterate very bright spectra, the simple and efficient device was adopted of depositing an exceedingly thin film of silver on the reflecting face of the prism. This, while not perceptibly diminishing the amount of transmitted light, increased markedly that of the reflected beam. Sunlight was then tried with the same results. The prism was then replaced by a grating, and the experiment repeated on the diffraction spectrum. In this all the colored spaces yielded apparently in an equal manner, and all disappeared at the same moment. On diminishing the illumination, all the colors came into view apparently at the same time. The author concludes: 1st, that in the prismatic spectrum the luminous intensity increases from the more to the less refrangible spaces, its maximum being not in the yellow, but in the red. This is due to the action of the prism, which narrows and as it were condenses the colored spaces more and more as we pass toward the red, increasing the intensity of the light as it does that of the heat; 2d, that in the grating or diffraction spectrum the luminous intensity is equal in all the visible regions, all the colors being simultaneously obliterated by an extinguishing light. The distribution of heat is therefore that of light.—(*Am. J. Sci.*, III, xviii, 30, July, 1879.)

Cornu has contrived a spectroscope intended especially for the study of the ultra violet rays. The object-glass alike of the collimator and the observing telescope is an achromatic lens, consisting of a double convex lens of quartz and a plano-concave lens of calc-spar, both cut perpendicular to the optic axis. This combination is especially useful for the ultra violet rays, allowing all the rays to pass that reach us through our atmosphere, and being almost absolutely achromatic for them; so that the adjustment required for different parts of the spectrum is almost nothing. The prism used may be of calc spar, though it absorbs rays of the highest refrangibility; or of quartz, though if the axis is parallel to the optic axis, the double refraction interferes. This is obviated by using a prism made of two halves of contrary rotation, the interior face being perpendicular to the axis. To obtain a double dispersion, the two prisms of quartz have their bisecting planes perpendicular to the optic axis, but having opposite rotatory power.—(*J. Phys.*, viii, 85, June, 1879.)

Lamansky has proposed a special form of spectroscope for studying fluorescent liquids. Ordinarily a glass plate has intervened between the liquid and the spectrum made to enter it. Hagenbach places the slit and the prism-axis horizontally and projects the spectrum on the free surface of the liquid. The author's spectroscope consists of a graduated circle carrying the collimator and telescope, and movable to any angle in the vertical plane. A mirror sends the light into the collimator, beyond the lens of which and in the same tube is a direct-vision prism. The spectrum is thrown on the surface of the liquid contained in a small vessel on a movable table attached to the stand. It passes from it into the observing telescope, whose focal distance is shortened by a second object-glass removable at will. The circle is divided for the purpose of measuring the angles of incidence and emergence.—(*J. Phys.*, viii, 411, December, 1879; *Nature*, xxi, 267, January, 1880.)

Liveing and Dewar have studied the conditions of reversal of the lines of metallic vapors. They used at first a tube, the closed extremity of which was heated to incandescence in a furnace. The metal contained in the tube volatilizes; the light given by the bottom of the tube and by its walls gives alone a continuous spectrum; but before reaching the spectroscope it traverses the vapor. In the early experiments an iron tube 15^{cm} in diameter and 80^{cm} long was used, protected externally by a glaze. It was heated for 30^{cm}, the upper extremity of the tube being open and covered with a plate of mica or glass. A slow current of hydrogen prevented the vapors in the upper end of the tube from oxidizing. The collimator of the spectroscope had its axis in line with that of the tube. In this way the green thallium line, the blue indium line, the lines *b*, and some blue lines of magnesium were reversed. The temperature not being sufficiently high, the authors next used a block of lime, having a hole bored in its axis, 6 or 7^{mm} diameter, into the lower end of which a lateral hole opened for the insertion of an oxyhydrogen jet. Or two lateral holes may be bored opposite to one another and the two carbons of a voltaic arc introduced. Similar crucibles of carbon were also used. By means of a mirror placed over the opening the light was reflected to the spectroscope. In this way the reversal was accomplished of 13 of the 31 lines of potassium, of 4 of the 12 of sodium, of 6 out of 21 of barium, of 10 out of 34 of strontium, and of 11 out of 37 of calcium. Beside these, 4 lines of lithium, 1 of cæsium, 5 of magnesium, and 2 of aluminum were also reversed.—(*J. Phys.*, viii, 385, November, 1879. From *Proc. Roy. Soc.*, xxvii, 132, 350, 494, 1878; xxviii, 352, 367, 471, 1880.)

Peirce has called attention to the fact that a line in the diffraction spectrum (whether light or dark) must be shifted from its normal position in case another line falls very near it. Neighboring lines must be attracted if both are bright or both dark, and repelled if one is bright and the other dark. The reason assigned is that the lines are only maxima or minima of light, and the differential coefficient of the sum does not vanish at the same points as the differential coefficients of the separate terms. The shifting will be the greatest in the case of a faint line near a very intense one. The author has succeeded in shifting the position of lines by measurable amounts—one or two seconds.—(*Nature*, xxi, 108, December, 1879.)

Kundt has observed the phenomenon of anomalous dispersion in sodium vapor. In preparing to reverse the sodium line for a lecture experiment, he perceived that when the sodium vapor was very dense and the dark line very broad a peculiar bend outward appeared at the ends and on opposite sides of the line. The cone of sodium vapor in the Bunsen flame acts as a prism with its refracting edge horizontal and turned upward. If glowing sodium vapor give dispersion, this cone should give, with horizontal rays passing through it, a vertical spectrum, and if the rays have also passed through a glass prism with a horizontal refracting angle, a spectrum of the form above described should be obtained. From the position the refractive index of the vapor is greatest for those rays which are most deflected downward. The refractive index increases as the band is approached from the red side, is less on the green side, and then rapidly increases again.—(*Nature*, xxii, 302, July, 1880.)

Schuster has given an account of the spectra of lightning observed by him in Colorado during the summer of 1878. He used a direct-vision spectroscope furnished with a slit capable of micrometric movement. A bright line in the focal plane served as a reference mark. The observations were limited to the yellow and the green regions from wave-lengths 5000 to 5800. In making a measurement, the slit was displaced until the line to be measured was coincident with the reference line. The next morning its position was determined by reference to the solar spectrum. A continuous spectrum was seen many times. Bright nitrogen lines were often seen, those of wave-lengths 5002 and 5681 especially. Three bands of wave-lengths, 5592, 5334, 5182, were noted, and a fourth about 5260. Of these, 5182 belongs to nitrogen, and 5592 and 5260 are characteristic of the oxygen discharge at the negative electrode. The band 5334 is the most brilliant of the two green bands of the spectrum of oxygen taken at a low temperature.—(*Phil. Mag.*, V, vii, 316, 1879; *J. Phys.*, viii, 275, August, 1879.)

Russell and Lapraik have discovered that many liquids, ordinarily assumed to be colorless, give absorption bands when light passes through them on its way to the spectroscope. The phenomenon was first noticed with alcohol; and then it was perceived that water contained in a tube 6 feet long gave a very distinct absorption band in the orange, corresponding very closely with Piazzi Smyth's rain band and with the band seen by Janssen in 330 feet of steam. No variations in this band were observed by varying the source of supply, the temperature, or the substances held in solution. Other colorless liquids also gave bands. Ammonia gave four bands; ethylamine also four, but different in character; hydrogen peroxide, one; ethyl alcohol, one; amyl alcohol one; aldehyde and acetic acid, each, one; benzene and toluene, three each; aniline and toluidine, each, three; turpentine, two. These results are regarded as preliminary, and will have further investigation.—(*Nature*, xxii, 368, August, 1880.)

Rood has compared the color of the spectrum to which Newton gave the name "indigo" with the actual color of indigo itself, and finds it to be a representative of an entirely different region of the spectrum. He shows: 1st, that the color of indigo is really a greenish blue when it is used as a pigment or in solution; 2d, that the color of the dry cake is not only very black, but is variable according to the mode in which it is handled. He concludes, therefore, that, taking all this into consideration, it would appear desirable to allow the term "indigo" to fall into disuse, and to substitute for it "ultramarine," the color of the artificial variety being intended.—(*Am. J. Sci.*, III, xix, 135, February, 1880.)

Lord Rayleigh showed to the Physical Society of London a curious experiment in color combination, by mixing a blue solution of litmus with a red solution of potassium dichromate, and thereby producing a yellow solution. In a similar way, a colorless liquid may be obtained from a green solution of cuprous chloride in water and a red solution of rosaniline acetate in amyl alcohol. When both are placed in a bottle, the crimson solution floats on the green solution; but on agitating them, both colors disappear, the mixture becoming grayish-white.—(*Nature*, xxii, 133, June, 1880.)

Rood has presented to the National Academy a paper on memory for color and luminosity, in which he gives the results of some interesting experiments made to test the prevailing notion that we do not retain for ten seconds an exact memory of a given shade or tint. The apparatus used consisted of two disks so arranged that either could be made to overlap the other in any required proportion. These disks were of different colors, which blended into a given tint when they were rapidly revolved, a tint the percentage of whose components was known. Suppose in one case this was 43 parts of yellow and 57 of red. After looking at the revolving disk, an assistant disarranged the two and then proceeded to reproduce the tint, Rood himself deciding when it was reached. The reproduced color had 42.6 per cent. of yellow—a mean of many trials, when the time of the entire experiment was not over a minute. The error here was not over one-half of one per cent. When an hour elapsed, the error was 2.2 per cent. Twenty-four hours afterward the error in reproducing the color was 4.5 per cent. The same experiments tried by the assistant gave equally good results, as did also similar experiments tried with other color mixtures.—(*Nature*, xxi, 144, December, 1879.)

3. *Interference and Polarization.*

Guebhard has devised a simple method of producing the phenomena of Newton's rings in a permanent form. While the rings obtained are due to interference and give the colors of thin plates, they differ from Newton's rings proper in having the phenomena inverted, the greatest thickness of the film being at the center. To produce the rings a little collodion is dropped on a surface of mercury. It is drawn out on all sides into a thin iridescent film, which when hard may be floated off on to paper. Mastic varnish on the surface of water gives similar films. Drops of volatile mineral oil on mercury, or even the film of moisture condensed from the breath, give rings which of course are transient. At a meeting of the Physical Society of Paris, Guebhard projected these films on the screen; and showed that even the films condensed from the breath may exhibit phoneidoscopic properties. The various vowels being pronounced so that the breath impinges on the surface of the cooled mercury, rings are obtained having certain forms more or less strongly characteristic of their different qualities of tone.—(*Nature*, xxi, 242, January, 1880.)

Michelson has communicated to the New York Academy of Sciences some interesting observations upon the diffraction and polarization effects produced by passing light through a narrow slit. If a fine adjustable slit be narrowed down very greatly, the colored diffraction fringes widen out until when the width of the slit is reduced to less than one fiftieth of a millimeter the central space only is seen, and appears of a faint bluish tint. Moreover the light so transmitted exhibits traces of polarization when regarded through a Nicol prism. As the slit is narrowed, the depth of the tint and the amount of polarization increase, until when the opening is only one-thousandth of a millimeter the color becomes of a deep violet and the light is completely polarized. Slits of obsidian give the best results, because finer edges can be worked on it. The plane of polarization is at right angles to the length of the slit.—(*Nature*, xxii, 133, June, 1880.)

Crova has published a note on the two forms of polarizing prisms, those of Nicol and of Foucault. In the former the two halves are cemented by Canada balsam; in the latter they are separated by a layer of air. In both cases the bases are oblique to the axis of the prism and this occasions a considerable loss of light both at entrance and emergence; to which, in the Foucault prism, must be added that lost by the internal reflections. Both Hoffmann and Duboscq constructed Foucault prisms with faces normal to the axis, but the loss of light internally remained. Prazmowski has made a polarizing prism which is like a Nicol, except that the halves are cemented with linseed oil, the faces being normal. More spar is required and the manufacture is long and difficult. Almost no loss of light, however, takes place internally, the index of the oil being 1.485, very near to the extraordinary index of spar, 1.483. The field is increased to 31°, against 21° in the Nicol and 8° in the Foucault. For photometric purposes especially, Crova regards this new prism of great advantage.—(*J. Phys.*, ix, 152, May, 1880.)

Govi has illustrated the laws of circular polarization by an exceedingly beautiful projection experiment, founded on the well-known fact that the spectrum obtained of the colors produced by the interference of polarized light contains one or more dark bands, corresponding to the colors extinguished by the interference. If the depolarizing plate be of quartz, the bands are moved along the spectrum to the right or left by rotating the analyzer. Govi's device consists in rotating the analyzer and the direct-vision prism together at the same velocity. A circular spectrum is thus produced, red at the center and violet on the edges, or the reverse. As the dark quartz band moves along the spectrum by an amount proportional to the rotation angle, interference will take place along this circular spectrum along points which form, geometrically, a spiral of Archimedes, which persistence of vision makes permanent. Thicker quartz gives two, three, or more interlacing spirals, forming a very striking optical experiment.—(*Nature*, xxii, 595, October, 1880.)

Klocke has discovered that in its action on polarized light, hyposulphite of lead is anomalous. It ordinarily polarizes circularly, but when plates cut perpendicularly to the optic axis, are viewed in a parallel beam of polarized light they appear unequally bright, being divided by dark bands into six sectors, opposite pairs of which are equally bright. Even in convergent light the usual ring system of uniaxial crystals is not seen, but in each sector there appears a figure characteristic of biaxial crystals, the plane of the optic axes being perpendicular to the neighboring edge of the crystal. It would thus appear that the six portions are compressed equally, each in a direction perpendicular to the neighboring face of the prism.—(*Nature*, xxiii, 209, December, 1880.)

Becquerel has published a memoir on the polarization of the sky. He finds that, contrary to the general opinion, the plane of polarization for a given point does not generally pass through the sun, but that the angle which this plane makes with the plane of the sun (a plane passing through the point, the sun, and the eye of the observer) varies from minute to minute so that the plane of polarization passes a little below the sun, between it and the horizon. If the point be in the northern or southern sky this angle is very small in the morning, increases to a maximum from nine to ten o'clock, disappears at noon, increases again to a maximum about 2 or 3 p. m., again diminishing and becoming zero as the sun sets. If the point be east or west, coincidence of the two planes is not seen, though a minimum is observed about noon. At morning and evening the angle attains maxima, reaching even 6°. From these phenomena the appearance is as if the plane of polarization suffered a direct rotation, viewed by an observer whose head was toward the north and his feet toward the south. Since in a region perpendicular to the dipping needle, the rotation is sensibly zero, the author believes that it is due to the influence of the earth's magnetism—an opinion strengthened by the fact that he has just measured the amount of rotation of a polarized-light ray traversing a layer of carbon disulphide, under the influence of the earth's magnetism.—(*Ann. Chim. Phys.*, V, xix, 90, January, 1880; *J. Phys.*, ix, 51, February, 1880.)

Kerr has extended his electro-optical researches, and by the aid of new and improved apparatus has confirmed his early conclusions. The apparatus includes a paraffin-oil lamp; a Nicol with its principal section inclined 45° to the horizon; a cell for the liquid so arranged that the line of junction of the electrodes is horizontal; a system of compensating glass plates which can be submitted to a vertical traction by means of known weights; a neutralizing plate of glass of irregular structure, to compensate the double refraction of the cell; a hand-compensator; a vertical strip of glass which can be flexed by the hand parallel to the axis of the luminous bundle, designed to determine the direction of the double refraction produced in the liquid; and an analyzing Nicol inclined at 45° to the horizon and 90° to the principal section of the polarizer. When adjusted the light is completely extinguished and can be restored by the hand-compensator. The electric machine is then put into action. With carbon disulphide a fraction of a turn suffices to return the light, which instantly disappears again on discharging the conductor. The compensator shows a uniaxial double refraction like that of glass submitted to traction parallel to the lines of force. With nitrobenzene the light reappears only on drawing a spark from the second electrode. In a subsequent paper, Kerr formally enunciates the following law: "The intensity of electro-optic action of a given dielectric (or the difference of retardations of the ordinary and extraordinary rays) per unit of thickness of the dielectric varies directly as the square of the resultant electric force." On the question of stress he says: "The dioptric action of an electrically charged medium is closely related to the electric stress of the medium, the axis of double refraction coinciding in every case with the line of electric tension and the double refraction varying, certainly in CS_2, and probably in all other dielectrics directly and simply as the intensity of the tension."—(*Phil. Mag.* V., viii, 85, 1879; ix, 157, 1880; *J. Phys.*, viii, 414; ix, 255, 1880.)

ELECTRICITY.

1. *Magnetism.*

Carré has introduced into Paris the manufacture of magnets of superior quality made of cast iron. His process is as follows: A soft and very slightly carburetted metal is melted in earthen crucibles, and just before running it into the moulds 10 or 15 per cent. of steel filings are added. In order to produce a metal which will stand tempering at a cherry-red heat, there is added either 1 to 1.5 per cent. of nickel, with 0.25 per cent. of copper, or 2 per cent. of tin and 0.5 per cent. of copper. —(*Nature*, xxi, 359, February, 1880.)

Obalski has described to the Academy a very neat magnetic experiment. Two magnetic needles are hung vertically by fine threads, their unlike poles being opposite one another. Below them is a vessel containing water, its surface not quite touching the needles, which are hung so far apart as not to move toward one another. If the level of the water be now quietly raised by letting a further quantity flow in from below, as soon as the water covers the lower ends of the needles they begin to approach, and when they are nearly immersed they rush together. The effect appears to be due to the fact that when the gravitation force downward is partly counteracted by the upward hydrostatic force due to immersion, the magnetic force is able to assert itself, being greater.—(*Nature*, xxii, 133, June, 1880.)

Mayer has contrived an ingenious magnetic experiment to illustrate molecular groupings and molecular actions. Sewing needles are magnetized all in the same direction. They are then pushed through small pieces of cork up to the eye. On placing them in water they float vertically, with the point downward. Since the similar poles are upward, they repel each other. These needles represent molecules; their magnetism the repulsive force. To obtain an attractive force, a bar magnet is held vertically over the water, so that the pole of contrary name to the tops of the needles shall be downward. The needles are attracted and approach each other, producing groupings which depend on the number of the needles, their initial position, and the impulses given. Twenty-three of these groupings are represented in the paper, the most complex figures being formed of twenty needles; though the author has formed much more complex ones, more than fifty needles having been grouped in one of his figures. The author employs these groupings to illustrate many of the laws of both molecular and atomic arrangement. When projected by means of a vertical lantern they are very striking. —(*Am. J. Sci.*, III, xv, 276; xvi, 247; *J. Phys.*, viii, 32, January, 1879.)

Barker has communicated to the National Academy the results of some experiments made to test the alleged incorrectness of Arago's explanation of the magnetism of a wire through which a current is passing, *i. e.*, that the wire is itself magnetic. Bache had explained the result by supposing the iron filings, held by the wire in Arago's experiment, became themselves magnets under the influence of the current, and so became attached to each other rather than to the wire. In proof of this he says that if a card be scraped along on the top of the wire the ring of filings is broken and the whole mass falls. Barker used in his experiments a quantity magneto-machine made by Wallace, the current from which was capable of heating three feet of quarter-inch gas pipe to bright redness in a minute. When this current was passed through a copper wire, a 5-inch iron spike held close under the wire was markedly attracted by it; and when placed in contact with the lower side of the wire, adhered readily magnetically, placing itself with its axis perpendicular to that of the wire. This result was the same when the conducting wire was red hot. In a second experiment the wire passed through a hole in a large sheet of glass. When this glass was sprinkled with iron filings concentric magnetic curves, complete and partial, were formed round the wire for a distance of 20 inches. These experiments seemed conclusive that the copper wire really was itself a magnet in this case.—(*Nature*, xxi, 145, December, 1879.)

Lemström has described to the Physical Society of St. Petersburg an experiment of great apparent significance. He finds that a ring of insulating material, when rotating about its axis of symmetry with a high velocity, acts like a galvanic circuit and produces a magnetic field in the space within it. He explains it by supposing that the ether in the insulator, being dragged along by the ring, produces vortical motion of the ether in the central space, which vortical motion be conceives to be the essential condition of a magnetic field. On this experiment the author founds his theory of terrestrial magnetism. Since rotating an iron bar within an insulating medium ought to magnetize the bar, the earth being a magnetic body rotating in an insulating medium ought to be magnetized by its rotation.—(*Nature*, xxii, 89, May, 1880.)

Piazzoli has studied the influence of magnetism on the tenacity of iron. Wires were hung between two hooks and ruptured by pouring water into a vessel suspended from them. These wires were 35^{cm} long, and were inclosed in a helix of four layers of wire. The current was made to traverse these layers all in one direction, or two in one direction and two in the opposite, the effect of heating being thus eliminated. The wires annealed in charcoal broke at 1260 to 1306 with, and 1213 to 1270 without magnetization. Wires annealed in carbonous oxide 1732.4 to 1742.7 with, and 1703.62 to 1719.87 without the current. Those annealed in hydrogen, 1289.5 to 1310.1 with, and 1263 to 1299.7 without the magnetism. The values are about from 1 to 3 per cent. greater for the magnetized than for the unmagnetized wires, showing that the tenacity of iron increases on magnetization.—(*Nature*, xxii, 89, May, 1880.)

Righi has sought to harmonize the discordant results as to the changes in the length of iron bars when magnetized. By means of a mirror method which magnified the elongation 8,000 times, he ascertained tha (1) magnetism produces an increase in iron and steel in the dimension of the direction of magnetization; (2) a part of this increase remains after the current ceases, being more or less according to the coercive force; (3) when the current is not very strong, the elongations are proportional to the square of the current strength; (4) after a strong current has been sent through the spiral, a weak current sent in the opposite direction produces a shortening, though the bar, even when demagnetized by it, remains longer than normal; (5) during reversal of polarity the length becomes momentarily less, the effect being oscillatory; (6) a bar shortens at the instant of closing the circuit, when the current traverses it directly; (7) it elongates on opening, but by a less amount; (8) on reversal, the bar elongates and oscillates; (9) the contraction is greater if the bar has been longitudinally magnetized previously; and (10) some bars show a tendency to take spiral magnetization, *i. e.*, to rotate the magnetic axes of their molecules in the direction of the turns of the helix.—(*Nature*, xxii, 543, October, 1880.)

Becquerel has published an extended memoir on the magnetic properties of nickel and cobalt compared with those of iron, using the oscillation method, the differential method, and the electromagnetic-balance method, for comparison, confining himself to the magnetism developed by induction, and not the magnetism which remains permanent. The author's most important conclusion is that for very feeble intensities, under conditions very far from saturation, or with substances in which the magnetic particles are sufficiently removed, so as not to react the one upon the other, the effects developed in the molecules of nickel and of iron at the ordinary temperature appear to lie very near each other.—(*Ann. Chim. Phys.*, V, xvi, 227, February, 1879.)

Hodges has contrived a new instrument for determining the inclination of the needle, founded on the fact that the magnetic polarity of a bar of soft iron is greatest when the bar lies in the line of the dip. In place of a single bar, however, the author uses two, joined to each other at right angles. When the two branches make equal angles with the line of dip, the ends next the junction are of opposite polarity; and if similar, will neutralize one another so that a needle suspended near them will remain unaffected. The results on trial were very accordant under different conditions.—(*Am. J. Sci.*, III, xvii, 145, February, 1879.)

Rowland and Jacques have determined the diamagnetic contents of bismuth and calc-spar in absolute measure, the former contributing the theory, and the latter making the measurements. These latter consisted of two: 1st, the determination in absolute measure of the magnetic potential of the field used; and, 2d, the determination of the time of vibration and the other constants of the little bars of the substances when suspended in this field. The diamagnetic constant of bismuth along the axis was found to be —.000000012554; and for calc-spar —.000000037930, in absolute measure.—(*Am. J. Sci.*, III, xviii, 360, November, 1879.)

2. *Electromotors.*

Hoorweg has investigated the conditions of the production of electricity in the voltaic cell, and has advanced a thermic theory of its origin. The following are his conclusions: 1st. Wherever two conductors are in contact, the heat movement has the production of electricity as a consequence; hence a constant electric difference exists between the bodies. 2d. Whenever the sum of the differences of potential existing in a circuit is different from zero, a permanent current is produced. 3d. This current absorbs heat at certain of the points of contact and evolves it at others. 4th. All voltaic currents are thermo-currents. 5th. All chemical actions in the cell and in apparatus for electrolytic decomposition are a consequence of the passage of the current.—(*Ann. Phys. Chem.*, II, ix, 552, 1880; *J. Phys.*, ix, 352, October, 1880.)

Varenne has studied the phenomenon of the passivity of iron in nitric acid as when employed as the positive plate of a Grove battery or the positive electrode of a voltameter cell containing nitric acid. He concludes that this peculiar effect is due to a film of nitrogen dioxide which collects upon the surface of the iron and protects it from further chemical action. This film, he asserts, is apparent when the surface of the iron is examined under the microscope. If a current of carbon dioxide or of hydrogen gas is passed through the liquid the passivity ceases and the iron is dissolved. Moreover, on placing the iron plate *in vacuo* nitrogen dioxide is evolved from it.—(*Nature*, xxi, 117, December, 1879.)

Pellat has examined the standard cell proposed by Latimer Clark, and finds that it is not entirely free from variations in its electromotive force. According to his observations two of these cells may differ from each other by a quantity equal to the one-hundredth of the electromotive force of a Daniell cell. The method employed was to couple up the two cells in opposition to one another, and then by means of an electrometer to measure the residual difference of potential.—(*Nature*, xxi, 117, December, 1879.)

Debrun has constructed an ingenious capillary electromotor, based on the theorem established by Lippmann, that if a mercury surface be deformed by mechanical means there is produced an evolution of electricity which tends to arrest the motion of the mercury. Through a capillary tube mercury is caused to run drop by drop, acidulated water being introduced, by means of a reservoir at the top, between each globule. Wires are connected with the masses of mercury at the upper and lower ends of the tube, and a current is observed to flow on closing these in the direction in which the globules move. The tube actually used was 2.5^{mm} in diameter at top and 1^{mm} at bottom, 30^{cm} long, containing not less than 20 nor more than 35 globules. The electromotive force under these circumstances is 1.4 volts, so that with Wollaston's points it can decompose water. The energy, however, is not very great, since it is produced by the fall of only two kilograms of mercury per hour through only 25^{cm}. In allowing the mercury to run for twenty-four hours sufficient current was developed to silver strongly a five-centime piece. The internal resistance of a column of acidulated water 1^{mm} in diameter and 30^{cm} long being so considerable, a high-resistance galvanometer should be used to test the currents produced by this instrument.—(*J. Phys.*, ix, 28, January, 1880.)

Barrett has communicated to the Physical Society of London the fact that the motion of a chalk cylinder under a metallic surface generates an electric current, having an electromotive force of rather over one-third of a volt. The strength of the current depends on the rapidity of the rotation and the pressure on the chalk surface; the latter only diminishing the very high internal resistance. The discovery, he says, resulted from a suggestion made to him four or five months before, to try whether Edison's motograph telephone receiver could be used as a transmitter. Then his experiments were not successful, but now he finds that the voice is faintly but accurately transmitted on speaking into the receiver while the chalk is made to rotate. But Edison had himself published the same fact in the *Scientific American* one or two years before, and had given a figure of several of these chalk cylinders connected in series for the purpose of producing a current of high potential.—(*Nature*, xxi, 417, March, 1880.)

Blyth has communicated to the Royal Society of Edinburgh the general fact that electric currents are produced by the mere friction between conducting substances. Since for all pairs of metals yet tried these currents are in the same direction as the thermo-current produced by heating the junction of the same two metals, the author thinks that they may have in part a thermo-electric origin; but another part may be due to the currents suggested by Sir William Thomson as the cause of friction, and still a third part to the force of contact between films of air or oxide on the surfaces. One of the motors constructed consists of a cylinder of antimony arranged so as to be rapidly rotated, and a plate of bismuth which is pressed hard against it by a spring. When included in the circuit with a microphone and a Bell telephone, the current from it is quite sufficient to serve for the transmission of musical sounds and loud speaking. By using a cylinder of bismuth on which a bent sewing needle presses as it rotates, a very good receiver is also produced. The author ascribes the result to a heat change, analogous somewhat to that observed in the Trevelyan rocker.—(*Nature*, xxii, 330, August, 1880.)

Heraud has proposed a new voltaic cell, the negative plate of which is zinc immersed in a concentrated solution of ammonium chloride, while the positive consists of a plate of carbon surrounded by fragments of carbon mixed with about an equal weight of mercurous chloride (calomel) in powder. In action the mercurous chloride loses chlorine, and is reduced to metallic mercury; the zinc acts on the ammonium chloride, producing zinc chloride and ammonia; and the ammonia water and chlorine unite again to reproduce the ammonium chloride. It is claimed that this battery does not polarize, and can be used on a closed circuit. Its electromotive force is not far from that of a Daniell cell.—(*Ann. Chim. Phys.*, V, xvii, 512, August, 1879.)

Niaudet has constructed a voltaic cell, the plates of which are also zinc and carbon; but the former is immersed in a solution of common salt and the carbon in a porous cup containing commercial chloride of lime (a mixture of chloride, oxide, and hypochlorite of calcium). Under the action of the polarizing hydrogen, the hypochlorite is decomposed into hydrochloric acid, which forms calcium chloride with the lime present, and water; so that the salts produced by the battery when in action are zinc chloride and calcium chloride. Since both are extremely soluble, the liquid preserves its limpidity, and no insoluble salt is formed. The electromotive force of this battery is 1.6 volts. It polarizes only when closed on short circuit, from which it recovers rapidly. Its chief merit is that, like the Leclanché cell, the zinc is not acted on until the circuit is closed. To prevent escape of odors, the opening in the porous cell is closed with a waxed cork.—(*J. Phys.*, ix, 18, January, 1880.)

Niaudet has given an illustrated description of the Noë thermopiles constructed by Hauck, of Vienna, and exhibited in Paris. The elements used are German silver, employed in the form of wire, four from each junction, and an antimony alloy cast in a mould. Each pair has an electromotive force equal to 0.1 Daniell cell, for a temperature at which the ends are below redness. It resistance is 0.1 of a Siemens unit per element.—(*J. Phys.*, viii, 230, July, 1879.)

D'Arsonval has suggested an improvement in Plante's secondary batteries, which, as is well known, consist of two sheets of lead immersed in dilute sulphuric acid. The action is limited at the cathode by the hydrogen bubbles which form there, and at the anode by the low conductivity of the lead peroxide film which forms over its surface. The first of these difficulties d'Arsonval obviates by electrolyzing a salt of zinc instead of a dilute acid. The second he avoids by increasing the surface of the anode, employing for this purpose shot heaped about a carbon plate. The liquid employed is a strong solution of zinc sulphate. While charging, zinc is deposited upon the surface of a lead plate, or, better, upon a free surface of mercury amalgam, sulphuric acid being produced at the same time. Its electromotive force is claimed to be 2.1 volts.—(*Nature*, xxi, 409, February, 1880.)

Breguet has published a memoir upon the theory of the Gramme machine, and on the cause of the dissymetric position of its brushes. The following are his conclusions: 1st. The theory of the Gramme and von Alteneck machines is directly connected with that of Barlow's wheel and Faraday's machine, and these latter machines rest on the first principle established by Ampère, *i. e.*, a movable current tends to place itself in such a position that the observer who personifies it sees the south pole on his left and the north pole on his right hand. 2d. The soft iron armature of the von Alteneck machine serves only to re-enforce the magnetic field in the region where the wires of the movable circuit revolve. 3d. The annular armature of soft iron of the Gramme machine has the same influence as the preceding armature, but this is not its characteristic function. This function consists in shielding the internal wires of the bobbin spires from the normal action of the lines of force of the field. 4th. The angular displacement of the brushes of the preceding machines cannot be attributed to the retardation of the demagnetization of the soft iron ring alone, since this displacement still exists and may even become still more considerable in those forms derived from these machines where there is no soft iron armature.—(*Ann. Chim. Phys.*, V, xvi, 5, January, 1879.)

3. *Electrical measurements.*

Pellat has devised a method for measuring electromotive force which may be applied to a battery or may be used to determine the difference of potential between two metals in contact. The principle consists in opposing to the cell to be measured an electromotive force variable at will continuously and by amounts exactly known by a simple reading, until the compensation is exact. The instrument resembles that of Du Bois Reymond, but it uses a capillary electrometer in place of a galvanometer, and thus, while more delicate and more rapid, polarization is completely avoided. Moreover, the sensitiveness of the method is independent of the resistance of the cell, batteries of 10,000,000 ohms resistance being measured with ease. For weak electromotive forces, the delicacy is one ten-thousandth of a Daniell cell; for stronger ones, to one two-thousandth of a Latimer-Clark cell. The applications of the method to determine the contact-potential are very ingenious.—(*J. Phys.*, ix, 145, May, 1880.)

Debrun has made a useful modification of Lippmann's capillary electrometer. In the original instrument, in a tube a millimeter in diameter, the mercury level changed only 3^{mm} for a difference of potential of one volt, and to measure small fractions Lippmann used a microscope. In the new instrument this delicacy is secured by making the tube inclined to the vertical, the effect increasing with the angle. A glass tube 7^{mm} in diameter is drawn out so as to give a capillary tube slightly conical, and a good millimeter in diameter and 20^{cm} long. This is bent into a **Z**-form, the connecting portion being placed horizontally, but fastened to a movable board, so that its inclination may be adjusted. The ends of the tube open into reservoirs. It is filled with mercury and acidulated water, as usual, the end of the mercury column being adjusted to occupy three-quarters of the horizontal part. Electrical connections are made with the mercury in each of the reservoirs. The calibration is effected by using a battery of known potential, increasing the cells.—(*J. Phys.*, ix, 160, May, 1880.)

Niemöller has found the telephone capable of determining very quickly and accurately the resistance of liquids. It is substituted for the galvanometer in a Wheatstone's bridge, and an induction current is used. If the resistances to be compared are a large liquid resistance and a Siemens resistance box, so that the electrodynamic constants are very small; and if also a German-silver or platinum wire be used as measuring wire, it is found that in the position where the galvanometer shows no deflection, the tone in the telephone has a well-marked minimum of intensity. In a liquid resistance of 2,000 units a variation of even four units may be detected readily.—(*Nature*, xxi, 309, January, 1880.)

Trowbridge has studied the conditions which cause the ticking of the time-clock of Harvard College Observatory, transmitted electrically by wire from Cambridge to Boston, to be heard on all the telephone circuits in the neighborhood of the line. He shows from theoretical considerations that the usual explanation of induction between the wires is erroneous, and that the effects observed on telephonic circuits, which have usually been attributed to induction, are really due to the earth connections and to imperfect insulation. As the result, then, is due to the fact that the wires on which the sound is heard obtain their current by tapping the ground at places of different potential, the author made experiments to determine the equipotential surfaces formed by the ground of the time signal-service. By running a wire 500 or 600 feet, placing its terminals in moist earth, and including a telephone in the circuit, the ticking of the clock could be readily heard in a field an eighth of a mile distant from the observatory; and at one point a mile distant the ticking was heard with only 50 feet of wire. Behind the observatory no result was had, though at no point were earth currents absent. "Theoretically," the author concludes, "it is possible to-day to telegraph across the Atlantic Ocean without a cable"; "practically the expenditure of energy on the dynamo-electric engines would seem to be enormous."—(*Am. J. Sci.*, III, xx, 138, August, 1880.)

Hill has devised an electro-dynamometer for use especially with strong currents, which in general is similar to Trowbridge's instrument, but differs from it in the manner of determining the deflective power of the current. To the suspended coil a pointer-rod is attached, on opposite sides of which silk threads are fastened, which lead over pulleys on the side bars to small pans, one on each side of the instrument. When the deflection has taken place weights are added to the pan on the opposite side until the pointer-rod returns to zero. In the instrument as constructed a current of 20 webers required about half a gram weight, and one of 100 webers a weight of 13.2 grams. The instrument works well and gives uniform results.—(*Am. J. Sci.*, xix, 10, January, 1880.)

Hughes has devised an apparatus, which he calls an induction balance, for comparing induced currents. It consists (1) of a battery of three Daniell cells, the current of which traverses a microphone with an attached clock for producing the sounds; (2) of the balance proper; (3) of an electric sonometer; and (4) of a receiving telephone. The balance itself is formed of four equal coils, a decimeter in height, 5.5^{cm} external diameter, with a space of 3^{cm} internally, each covered with 100 meters of No. 32 covered copper wire. The four coils form two groups placed beyond each other's influence. At each end, therefore, there are two coils, one inducing, the other receiving the induction, placed end to end, and about 5^{mm} apart. The electric sonometer is formed of two similar inducing bobbins fixed at the ends of a horizontal rule 40^{cm} long, divided into millimeters. Along this rule moves a receiving coil. The electric current from the microphone reaches a commutator which directs it into the balance or into the sonometer, where it traverses the inducing coils. The telephone circuit passes through the receiving coils, first the two on the balance, in opposite directions, and then that on the sonometer. No sound is heard in the telephone if the receiving coil in the latter case be equidistant from the inducing ones. No sound is heard in the balance coils if they are empty; but if a fragment of metal be placed between them, a sound is heard louder according to the character of the metal. The current is passed alternately into the balance and the sonometer, and the coil of the latter is displaced until the sounds have the same intensity in each. The action of the metal is then indicated on the graduation of the sonometer.—(*Phil. Mag.*, V, viii, 50, 551, 554, 1879; ix, 123, 1880; *J. Phys.*, viii, 353, 1879; ix, 376, 389, 393, 1880; *Ann. Chim. Phys.*, V, xix, 561, April, 1880.)

4. *Electric spark and light.*

Spottiswoode has experimented on the use of the alternating current of a De Meritens magneto-electric machine for exciting the induction coil. He used a coil giving a 50^{cm} spark, the reversals being 1,300 per minute; no interrupter was therefore needed. Under these conditions sparks were obtained only 18^{cm} long, but they were as thick as an ordinary pencil. They showed a brilliant point at each extremity of a tongue of yellow flame. When the current passed freely no spark proper appeared; but by blowing on one side, brilliant sparks may be made to pass.—(*Phil. Mag.*, V, viii, 390; *J. Phys.*, ix, 37, 1880; *Nature*, xxi, 433, March, 1880.)

Farmer has called attention to the fact, as a contribution to the history of electric lighting by incandescence, that in July, 1859, his house in Salem was lighted every evening by a subdivided electric light. A galvanic battery of three dozen six-gallon jars in the cellar furnished the electric current. On the mantel in the parlor were two electric lamps, either of which could be lighted at pleasure or both at once by simply turning a little button. The light was soft, mild, agreeable to the eye, and more delightful to read or sew by than any light ever seen before. It was discontinued on account of the expense. On the cost of electric light as compared with gas Farmer says: "On the average one pound of illuminating gas will, if burned in an hour in five different burners, give fifteen candle lights to each burner, or seventy-five candle lights in all. One pound of illuminating gas possesses a sufficient store of energy to enable it to give out by combustion from 18,000 to 21,000 units of heat, or the equivalent of from 13,000,000 to 16,000,000 foot-pounds of work. This, if burned in an hour, would average from 200,000 to 260,000 units of work per minute, or say from 3,000 to 3,500 foot-pounds per minute per candle light. Now a very large electric light, say ten thousand candles, does not consume more than 15 or 20 foot-pounds of energy per minute per candle light. So it might not seem very extravagant to expect that one pound of gas per hour could be burned in a suitable furnace under a proper boiler, and steam be taken from this boiler to a steam-engine, and this engine drive a magneto-electric machine which should supply electricity to five electric lamps that would shed forth more light than could be given by five of the best gas lamps known, each lamp consuming at the rate of one-fifth of a pound of the best illuminating gas per hour."—(*Am. J. Sci.*, III, xvii, 65, January, 1879.)

Jamin has constructed a modification of the Jablochkoff candle, in which he has made use of the electrodynamic action of a coil of wire to keep the arc steady and pointing in one direction. The two carbons are parallel but inverted, hanging with their points downward. They have no insulating material between them. Surrounding these, and in their own plane, is a flat coil of wire through which the main current circulates. The trials with this lamp in Paris are said to have been successful.—(*Nature*, xxii, 355, August, 1880.)

Reynier has proposed an incandescent light in which the point of a thin stick of carbon presses against a fixed carbon contact, while on it laterally, a short distance above, a third piece of carbon makes contact. The current enters by this lateral carbon and traverses the carbon pencil to its pointed end, passing thence to the solid carbon support. The pencil becomes thus incandescent, emitting most light at its point. Its photometric value varies from five to twenty carcel burners, according to the current.—(*J. Phys.*, viii, 400, December, 1879.)

Siemens has presented to the Society of Telegraph Engineers a paper on recent applications of the dynamo-current to metallurgy, horticulture, and the transmission of power. By means of an electric furnace made of a black-lead crucible, the positive carbon entering through the bottom and the negative through the cover, steel had readily been melted. Using a moderate-sized dynamo-machine, consuming four horse-powers and producing 36 webers of current—equal to a 6,000 candle light—he raises a crucible 20^{cm} deep to a white heat in less than half an hour, and a kilogram of steel is fused in it in another half hour. This furnace utilizes one-third of the horse-power actually expended; and as the efficiency of the engine is one-fifth, that of the electric furnace is $\frac{1}{3}\times\frac{1}{5}=\frac{1}{15}$. As it takes theoretically 450 heat units to melt a pound of steel, the furnace would require $450\times15=6750$ heat units to be expended, or about the energy of a pound of coal. A ton of steel as ordinarily melted in an air furnace requires 2½ to 3 tons of coke; in a regenerative furnace about a ton. The electric furnace is economically superior to the air furnace and nearly equal to the regenerative furnace. When the paper was read, a pound of broken files was melted in a cold crucible, by means of a current of 72 webers, in fifteen minutes, and cast in a mould. With reference to the action of light on plants, the interesting experiments made by him in this direction were detailed, and an account given of the experiments now in progress to produce flowers and fruits without solar aid. Under the third head of his paper, Siemens described his brother's electric railway in Berlin, and its numerous applications.—(*Nature*, xxii, 135, June, 1880.)

Edison has finally determined upon the use of carbon filaments in his incandescent lamps. These filaments are constructed by cutting with a suitable punch, from a piece of Bristol board, a strip in the form of a miniature horseshoe, about two inches in length and one-sixteenth of an inch in width. These are laid in a wrought-iron mould, separated from each other by tissue paper, and heated first by a gas flame and then in a furnace to a white heat. After cooling, the charred fiber is sealed in a globe, which is then exhausted to one-millionth of an atmosphere. Subsequently, in experimenting with various fibers, Edison came to the conclusion that a natural fiber was more durable than an artificial one, and that Japanese bamboo furnished the best. The lamps which are now made on the large scale are constructed with these fibers.

Rowland and Barker have made a series of measurements to test the efficiency of Edison's lamp. They compared the loss of energy in the lamp, as measured in the calorimeter, with the amount of light emitted, measured on the photometer. The lamps used were five in number, four of them having carbons made from paper, and one a natural fiber carbon. The comparisons were made by having two lamps in circuit, one being in the calorimeter and the other on the photometer in the first experiment, and their positions being reversed in the second. No. 201, which gave a mean of 10.1 candles on the photometer, gave 3486 foot-pounds of energy in the calorimeter; No. 580, which gave 13.1 mean candle lights, evolved 3540 foot-pounds. But when No. 201 was made to give 28.9 candles, its energy was only increased to 4898 foot-pounds; and No. 580, which gave 33.5 candles, evolved only 5181 foot-pounds; the cost of doubling the light being one-half more energy only. No. 809 gave 14.3 candles, and used 3330 foot-pounds; No. 850 gave 9.2 candles, and consumed 2483 foot-pounds. No. 817, the fiber lamp, gave 17.2 candles for a consumption of 2708 foot-pounds of energy. The mean of the first two is 109 candles per horse-power of current; of the second two, 204.3 candles; of the third two, 133.4; and of the fourth, 209.6. Or, in the first, 6.8 gas jets of 16 candles, in the second 12.8, in the third 8.3, and in the fourth 13.1 gas jets would be yielded by each horse-power of current. From the efficiency of Edison's machine, the authors think that the yield per indicated horse-power of the engine would not be far from 70 per cent. of these values.—(*Am. J. Sci.*, III, xix, 337, April, 1880.)

Brackett and Young have also made measurements on Edison's lamp, in addition to others upon his Faradic machine. Comparison of the Edison dynamometer with the Prony brake showed that the latter registered 93.2 per cent. of the power transmitted by the former. In their first experiment, the power expended was measured by the dynamometer and the current by the copper voltameter. The total efficiency was found to be 82.3 per cent., and the available efficiency 78.7 per cent. In the second trial the energy produced was measured by the calorimeter, and the total efficiency was found to be 84.6 per cent., the available, 78.2 per cent. A third test gave 84.5 total, and 78.2 available efficiency. But one lamp was tested, No. 853, the carbon of which was from paper. The mean illumination was 10.1 candles; the resistance, hot, 99.6 ohms; the difference of potential, 74.33 volts; hence the current strength was 0.75 weber, and the lamp was consuming 0.075 horse-power. This gives 137 candles per horse-power of current, or 107 candles per horse-power at the dynamometer; a near correspondence with the preceding results.—(*Am. J. Sci.*, III, xix, 475, June, 1880.)

Morton, Mayer, and Thomas have published results of measurements of Edison's lamp No. 154. The resistance of the lamp when cold was 123 ohms; when giving 1.9 candles, 82 ohms; and when giving 18 candles, 75 ohms. The current strength was measured on a tangent galvanometer, the constant of which was determined on a copper voltameter. When the lamp was giving 0.07 of a candle, it was consuming 0.445 weber of current, equivalent to 0.024 horse-power. When it gave 14 candles, the current was increased to only 1.079 webers, equivalent to 0.116 horse-power. This latter result gives 120 candles to the horse-power of current, or, assuming 60 per cent. efficiency in the machine, 72 candles per effective horse-power.—(*Ann. Chim. Phys.*, V, xx, 275, June, 1880.)

Swan has continued his experiments on incandescent lighting, begun, as he claims, as long ago as 1860. He uses carbon filaments made from parchment paper, 3 inches long, 0.01 inch in diameter, weighing $\frac{1}{20}$ grain, sealed in exhausted globes. One of these has burned continuously for three months.—(*Nature*, xxiii, 104, December, 1880.)

CHEMISTRY.

By George F. Barker,

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CHEMICAL PHYSICS.

Angus Smith has suggested a new series of elemental molecules, the relative weights of which are produced by squaring the atomic weights and dividing by the equivalence. This idea was reached in the course of his investigations into the absorption of gases by charcoal, in which it appeared that the gases were absorbed in perfectly definite volumes. Thus, eight volumes of oxygen are absorbed for one of hydrogen; but as the former is 16 times as heavy, the weights absorbed are as 128 : 1. But this is $\frac{1}{2}(16)^2$; *i. e.*, half the square of the density, or half the square of the atomic weight, or half the product of the two. Of nitrogen 4.66 volumes are absorbed, or 14×4.66 by weight, 65.3; this number is $\frac{1}{3}(14)^2$. Of compound gases the law is different. Carbonous oxide is absorbed to the extent of 6 volumes, carbon dioxide $6+16=22$ volumes, marsh gas $6+4=10$ volumes, nitrogen monoxide $8+4.66=12.66$ volumes. Hence the new molecular weight of CO_2 is simply 22^2, &c.—(*Nature*, xix, 354, February, 1879.)

Thomsen has studied the relation between the total energy developed in the chemical reactions which occur in various kinds of voltaic batteries and the energy which appears in the form of current electricity. He used a thermal method of measuring the total energy, and found that the whole of the energy developed in the chemical change appeared as electric energy in Daniell's battery on closed circuit, and also in the other forms of battery in which the metallic surface of the negative electrode is not changed by the electrolytic process. When nitric acid is used as the electrolyte the same total conversion of energy takes place, but the gradual absorption by the liquid of reduction products diminishes the result.—(*Nature*, xxiii, 207, December, 1880.)

Hesehus has made a series of experiments upon the change in volume and elasticity undergone by palladium when it occludes hydrogen. Wires 500^{mm} long and 0.4^{mm} diameter were stretched in a tube of glass placed vertically and filled with diluted sulphuric acid, and made the cathode. By a cathetometer the elongation was directly measured during the absorption. The pure palladium wire elongated 5^{mm}, while wires of alloys with 25 per cent. of silver, platinum, and gold, elongated 11.7^{mm}, 6.14^{mm}, and 0.9^{mm} respectively. With six bichromate cells the action was complete in an hour. After removing the battery the shortening took place in the same order, though less rapidly; being for the palladium wire only 2.6^{mm} in 24 hours. The law of these variations was automatically recorded. The coefficient of elasticity of palladium pure fell from 15540 to 14000; and that of the silver alloy from 15240 to 12500.—(*J. Phys.*, ix, 365, October, 1880.)

Berthelot has quoted Pictet's experiments on the liquefaction of oxygen and hydrogen gases as illustrating his thermochemical views. The oxygen was prepared by heating potassium chlorate. Now, the reaction $K\,Cl\,O_3 = K\,Cl + O_3$ according to Berthelot evolves 11 calories. Hence, being exothermic and not limited by its inverse, it is not arrested by a pressure of 320 atmospheres. The hydrogen was prepared by the action of potassium hydrate upon the formate. Since $K\,CHO_2 + K\,O\,H = K_2\,CO_3 + H_2$ evolves 18.4 calories, this action is also exothermic and not limited by an inverse reaction. Hence, the gas should be evolved, as Pictet found it to be, at over 600 atmospheres. Exothermic reactions continue, then, whatever the pressure.—(*Ann. Chim. Phys.*, V, xv, 149, October, 1878.)

Thorpe has published the results of an extended research on the relation between the molecular weights of substances and their specific gravities when in a liquid state. He concludes: (1) that many isomeric liquids, even of the same chemical type, have not identical specific gravities at their boiling points, and hence not identical specific volumes. Since this occurs mainly in compounds of carbon and hydrogen, the inference is that the specific volume of one or both of these bodies is not absolutely invariable; (2) that oxygen, sulphur, and nitrogen have also variable specific volumes; (3) that there is no evidence that the specific volume of any other element is variable; (4) that the number of these latter atoms does not modify the volume, which is independent of the molecular complexity; (5) that the different members of a family of elements do not possess identical specific volumes, these volumes being periodic functions of the atomic weights; (6) that no evidence is afforded that the specific volume is modified by any variation in the affinity value of any element.—(*Nature*, xxii, 262, July, 1880.)

Violle has determined the specific heat and melting point of palladium, iridium, gold, and copper. For palladium the specific heat was found to be, at 0°, 0.0582; at 500°, 0.0682; at 1000°, 0.0782; at 1300°, 0.0842. For iridium, at 0°, 0.0317; at 500°, 0.0377; at 1000°, 0.0437, and at 1400°, 0.0485. Gold has a specific heat at 0° of 0.0324; at 900°, 0.0345, and at 1020°, 0.0352. The fusing point of silver was found to be 954° C. referred to the air thermometer; of gold, 1035°; of copper, 1054°; of palladium, 1500°; of platinum, 1775°, and of iridium, 1950°. —(*J. Phys.*, ix, 81, March, 1880.)

Victor and Carl Meyer, in determining the vapor density of chlorine by their new method, the chlorine being produced by dropping platinous chloride into the tube heated to 1200°, have found that at these high temperatures this gas has a density only two-thirds of that corresponding to the molecule Cl_2. Subsequently Crafts repeated the determination, using already-prepared chlorine, and found its density to be normal; a result confirmed by Victor Meyer, working in conjunction with Züblin. To reconcile these facts it seems to be necessary to admit that while free chlorine is stable at high temperatures, nascent chlorine is not, but undergoes dissociation into products not yet known. The results, however, obtained by the German chemists with iodine, which showed the same anomaly, were fully confirmed by Crafts. Its vapor has at 1570° two-thirds of its normal density. Bromine is intermediate, its vapor density being reduced only one-fifth at high temperatures, when the bromine was free, and one-third when it was nascent.—(*Ber. Berl. Chem. Ges.*, xii, 1426, 2066, 2202, 2204, 1879; xiii, 394, 399, 401, 405, 851, 1050, 1103, 1880; *C. R.*, xc, 183, 690; xci, 54; *Nature*, xxi, 461, March, 1880; *Am. J. Sci.*, III, xviii, 222, 1879.)

Offret has revised the calculations of Pictet by which he reached a density of 0.9883 and 0.9787 for liquefied oxygen, and has shown errors in them by which the density is reduced to 0.8655; a result close to 0.8402, which the author obtains by a different process of computation. —(*Ann. Chim. Phys.*, V, xix, 271, February, 1880.)

Berthelot has published a work in two volumes, entitled "Essai de mécanique chimique fondée sur la Thermochimie." One of the laws it establishes is the following: "Every chemical change effected without the aid of foreign energy tends toward the production of those bodies or of that system of bodies which evolves the most heat." Thus he shows that for the metals K, Na, Ca, Sr, Mg, Mn, Fe'' Zn, Cd, Pb, $(Cu_2)''$ $Hg,''$ Ag and $(Al_2)^{vi}$, less heat results from the formation of oxides, than from the formation of chlorides. Hence gaseous chlorine should decompose these oxides, producing chlorides and evolving oxygen. This, in fact, actually takes place provided the reaction is initiated by suitably raising the temperature.—(*J. Phys.*, viii, 402, December, 1879.)

INORGANIC.

Dumas has studied the property of occluding hydrogen possessed by certain metals, and finds that aluminum may occlude as much as one and a half times its volume of this gas, as well as traces of carbon dioxide. These gases were given out again when the metal was heated to redness in an exhausted tube. Magnesium exhibits a similar behavior; so that to obtain these metals pure, they should be distilled *in vacuo*. These observations may throw some light on the anomalous behavior of aluminum when used as an electrode in the voltameter.—(*Nature*, xxii, 89, May, 1880.)

Morley has made a series of careful analyses of air in order to ascertain the limits of the variation of the oxygen in a single locality. On

Loomis's theory that sudden depressions of temperature are caused by the vertical descent of cold air from the higher portions of the atmosphere, the author conceived that such air might well contain a smaller proportion of oxygen than the average. In preparation for testing the question, he has made a number of experiments with apparatus specially constructed. In proof of its accuracy, he states that the probable error of a determination of oxygen in the air, is the 7200th part; and the probable difference of two determinations on the same sample is the 5200th part. The air analyzed was taken in the open country during December, 1878, and January and February, March and April, 1879. The minimum of oxygen observed was found in a sample taken on the 26th of February, when it was 20.45 and 20.50 in two experiments. The maximum occurred in air taken on the 28th of December, 20.98 and 20.96 in two analyses.—(*Am. J. Sci.*, III, xviii, 168, September, 1879.)

Boussingault has investigated the production of oxygen from barium dioxide under diminished pressure, and shows that in a vacuum this substance parts with oxygen at a low red heat. Conversely at about the same temperature, but at ordinary pressures, oxygen is readily absorbed again from the atmosphere by the lower oxide. Barium oxide may be successfully employed, therefore, on the large scale for obtaining pure oxygen from the atmosphere. The difficulty hitherto experienced was the fact that at the high temperature necessary to decompose the dioxide under ordinary pressures, some molecular change took place which diminished largely its power of absorption.—(*Ann. Chim. Phys.*, V, xix, 464, April, 1880.)

Hautefeuille and Chappuis have announced to the French Academy the liquefaction of ozone. By the use of a very low temperature they have succeeded in producing from oxygen, by the silent electric discharge, a greater quantity of ozone than hitherto, this at —23° C. being 21 per cent. The ozonized oxygen was conducted into the cool tube of a Cailletet's apparatus and pressure applied. After a few strokes of the pump the gas appeared azure blue in color, which increased with the pressure to dark indigo blue. On suddenly expanding the gas under 95 atmospheres pressure, a mist appeared in the tube, indicating liquefaction.—(*Nature*, xxii, 560, October, 1880.)

Ogier has succeeded in effecting the combination of hydrogen chloride and hydrogen phosphide gases by compressing them together in a Cailletet's apparatus. When equal volumes of these two gases were compressed by a pressure of 14 atmospheres at 14°, combination took place and small yellow crystals, very brilliant, appeared in the tube. If the proportion had been accurately made and the gases were pure, they disappeared entirely, the walls of the tube being covered with the crystals with no trace of liquid. If, however, the upper part of the tube be warmed with hot water to 20°, a liquid layer appears. If now the tube be cooled slowly, maintaining the pressure at 60 to 70 atmospheres, a point is reached when combination takes place and crystals are formed. A partial vacuum is produced in the tube and the mercury rises. The liquid may also be obtained by a sudden compression and the solid by a sudden expansion, producing sufficient cold.—(*J. Phys.*, ix, 386, November, 1880.)

Maskelyne has examined two samples of material said to be crystallized carbon or diamond sand. The first was sent him by Mactear of Glasgow. On testing it he found (*a*) that it would not scratch either sapphire or topaz; (*b*) the particles polarized light; and (*c*) were not combustible, hence the sample was not diamond dust. Since evaporation with hydrofluoric acid caused it to disappear, it was probably a silicate. The second sample came from Hannay, also of Glasgow, and consisted of small crystallized particles, which in luster, in lamellar structure on the cleavage surfaces, and in refractive power, presented exactly the appearance of fragments of a broken diamond. They were inert in polarized light, they easily scored deep grooves in sapphire, and they were combustible, burning away entirely on platinum foil. The angle between the cleavage faces was 70° 29′, that of the diamond being 70° 31′.7. Hannay has himself given an account of the production of these diamonds, in a paper read before the Royal Society by Professor Stokes. This result is an outcome of his remarkable research on the solubility of solids in gases. He observed that when a gas containing carbon and hydrogen was heated under pressure in presence of certain metals, its hydrogen is taken by the metal, and its carbon is set free. If this evolution of carbon takes place in presence of a stable compound containing nitrogen at a red heat and under a very high pressure, the carbon is obtained in the clear transparent form of the diamond. The specific gravity of the crystals is 3.5, and they yield on combustion 97.85 per cent. of carbon. An iron tube 4 inches in diameter and half an inch bore was exhibited as one of the tubes used in the experiment. These tubes burst in nine cases out of ten.—(*Nature*, xxi, 203, 260, 404, 421, 426, 1879–'80.)

Cooke has made additional experiments in support of his early result which fixed the atomic weight of antimony at 120.00; a result obtained as a mean of fifteen analyses of five different preparations of antimony bromide. In the present paper he discusses the causes of error to which his previous method was liable, and concludes that they arise from the analytical process, and not from a want of purity of material; and further that they are to a great extent under control. He then details the results of experiments made with the volumetric method, by precipitating a known weight of antimonous bromide by a standard solution of pure silver. As a mean of five analyses, the percentage of bromine found was 66.6651, against 66.6665 given by the fifteen previous analyses, corresponding to an atomic weight of 120.01. The silver bromide formed in the last two experiments, on drying and weighing, gave two additional determinations—120.01 and 120.00.—(*Am. J. Sci.*, III, xix, 382, May, 1880.)

Humpidge has given an excellent *résumé* of the progress of discovery of new metallic elements, of which fourteen have been added to the list in about two years, eleven of these belonging, it is said, to the yttrium or cerium group. The first was Davyum, a new metal of the platinum group announced in 1877 by Kern; probably a mixture. Then follow ytterbium by Marignac, X by Soret, mosandrum by Smith, phillippium and decipium by Delafontaine, thulium and holmium by Cléve and Thalén, samarium by Lecoq de Boisbaudran, scandium by Nilson, norwegium by Dahll, and vesbium by Scacchi.—(*Nature*, xxii, 232, July, 1880.)

ORGANIC.

Thomsen, in a paper presented to the Berlin Chemical Society, has attempted to base a general theory of the structure of carbon compounds on thermal determinations. He does this by measuring (indirectly of course) the heat of dissociation of the carbon molecule, and from this and other data finding a thermal value for the combination of two carbon atoms, to form a gaseous compound, by four "links," by three, by two, or by one. He thence deduces a thermal value for each link. General equations are given for calculating the heats of formation of various isomers, assuming a certain linking of the atoms for each. In cases where various linkings may be assumed, a determination of the heat of formation may determine which linking, and therefore which structural formula, is the more probable.—(*Ber. Berl. Chem. Ges.*, xiii, 1388, 1392, July, 1880; *Nature*, xxii, 542, October, 1880.)

Beilstein and Kurbatow have examined the more volatile portions of the petroleum of Baku in the Caucasus, with a view of comparing them with the corresponding portions of American petroleum. It had been observed that for the same boiling point the Caucasus fractions had a greater specific gravity. Hence a distrust of these Caucasus illuminating oils, until it was shown that they had an illuminating power 10 per cent. higher than the American. The fractions obtained by the authors were: one boiling below 80°, with a gravity of 0.717; one from 80° to 85°, 0.733; one from 85° to 90°, 0.741; one from 90° to 95°, 0.745; one from 95° to 100°, 0.748; and one from 100° to 105°, 0.752. Below 80° American petroleum yields hexane of gravity 0.669, while between 95° and 100° it gives heptane of gravity 0.699. To ascertain the cause of this difference the 80° to 85° fraction was agitated with fuming sulphuric acid; but no aromatic hydrocarbons were thus detected. Since analysis gives the formula $C_n H_{2n}$, the fraction was examined for the olefines with bromine; but no action took place in the cold. On further study it appeared that these hydrocarbons belonged to a series obtained by hex-hydrogenating the aromatic hydrocarbons, the first member of which is hexahydrobenzene. Subsequent investigation showed the same series to be present in American petroleum, though in much smaller amount.—(*Ber. Berl. Chem. Ges.*, xiii, 1818, 2028, 1880.)

Vincent and Delachanal have determined the density and the expansion coefficient of methyl chloride at various temperatures. For this purpose they used a thermometric reservoir containing the liquid, which with its stem was carefully calibrated. The density found varied very regularly from 23°.7, where it was 0.99145, to 39°, with a value of 0.87886. The expansion coefficient was found to increase with the temperature, the ratio of the increase of the volume from t to $t+1$ degrees, to the volume at t, being at −30°, 0.001310; at −0°, 0.001920; at 40°, 0.002373.—(*Ann. Chim. Phys.*, V, xvi, 427, 1879.)

Friedel and Ladenburg have continued their investigations upon organic compounds containing silicon in place of carbon, and have now given the results of their study of the silico-ethyl series. Silicon, they say, acts in a group of carbon atoms like one of them, and nothing could resemble a hydrocarbon more perfectly than do silicon-ethyl and silicon-methyl. In their present paper they describe silicon hexaiodide $Si_2 I_6$, silico-oxalic hydrate $H_2 Si_2 O_4$, silicon hexethyl, $Si_2 (C_2 H_5)_6$, silicon hexabromide $Si_2 Br_6$, and silicon hexachloride $Si_2 Cl_6$. The latter has also been obtained by Troost and Hautefeuille.—(*Ann. Chim. Phys.*, V, xix, 390, March, 1880.)

De Forcrand has studied the production of new ultramarines by replacing the sodium which is contained in the ordinary blue variety, more or less completely by other metals and even by organic radicals. Unger had obtained a green ultramarine in which half of the sodium was replaced by silver; and Heumann another, yellow in color, in which this replacement was complete. When this latter body is heated dry with a metallic or organic chloride, chloride of silver is formed and also a new ultramarine. After treating of the production of the silver ultramarine and the regeneration of the blue variety from it, and of the transformation of the silver body into ultramarines of potassium and rubidium, greenish blue, of lithium, blue, of barium, yellowish brown, of zinc, violet, and of magnesium, gray, the author proceeds to describe the formation and properties of organic ultramarines. When the silver compound is heated with ethyl iodide, a gray slightly reddish body is obtained, which heated with sodium chloride gives ethyl chloride and blue ultramarine. It was therefore an ethyl-ultramarine. Similar ultramarines were obtained with the radicals allyl, amyl, and benzyl, and even with the quaternary ammoniums triethyl-phenyl-ammonium and tetramethyl-ammonium.—(*Ann. Chim. Phys.*, V, xvii, 559, August, 1879.)

Cooke has described a double tartrate analogous to tartar emetic, in which the potassium is replaced by silver, and which he calls therefore silver emetic, or argento-antimonious tartrate. Although previously observed, its properties have been only incompletely examined since it was in an amorphous condition. It is more soluble in water than at first supposed, requiring one hundred parts of boiling water and less than five hundred parts of water at 15° C. for its solution. Hence by dissolving in boiling water and allowing the solution to cool, colorless brilliant crystals were obtained belonging to the orthorhombic system. They blacken on exposure to light, and decompose at 200° with slight explosion, leaving spangles of metallic silver mixed with an amorphous powder of antimonous oxide. It contained 26.30 per cent. of silver.—(*Am. J. Sci.*, III, xix, 393, May, 1880.)

Grimaux and Adam have succeeded in effecting the synthesis of citric acid from glycerin. Since glycerin is tri-hydroxyl-propane and citric acid is hydroxyl-tri-carboxyl-propane, the theoretical conversion of the former into the latter requires only the substitution of three carboxyls for two hydroxyls and one hydrogen. Practically, this replacement was effected in several stages: first, by the action of hydrochloric acid on glycerin, dichlorhydrin, or hydroxyl-dichlor-propane, was produced. By chromic acid this was oxidized to dichloracetone or oxydichlor-propane. This, by the action of concentrated hydrocyanic acid, gave dichloracetone-cyanhydrin, or hydroxyl-cyan-dichlor-propane. By saponifying with hydrochloric acid, the corresponding acid hydroxyl-carboxyl-dichlor-propane was obtained. The sodium salt of this was treated with potassium cyanide, giving hydroxyl-carboxyl-dicyan-propane. And this, when saponified as before, gave hydroxyl-tricarboxyl-propane, or citric acid, identical in all its properties with that obtained from lemons. Since glycerin can be made from trichlorhydrin, which may be made by the action of chlorine on propylene, and since propylene can be made from marsh gas and carbonous oxide, marsh gas itself being producible from carbon and hydrogen, the synthesis is complete from the simple elements up to citric acid.—(*Nature*, xxii, 585, October, 1880.)

Rosenstiehl has given the processes by which Baeyer has succeeded in synthesizing indigotin, the coloring matter of indigo. Two of these are described, in both of which cinnamic acid is taken as the point of departure. On nitration, this acid yields orthonitro-cinnamic acid; and this is converted (*a*) into orthonitro-phenyl-propiolic acid by brominating and subsequently saponifying; or (*b*) into orthonitro-phenyl-oxyacrylic acid by treatment with hypochlorous acid and subsequent saponification. The action of heat alone converts this latter acid into indigotin, a temperature of 110° C. being sufficient. But the action is complex and the yield is small. Orthonitro-phenyl-propiolic acid is converted into indigotin by heating it with a mixture of alkali carbonate and glucose, to 110° C. The action is regular, the indigotin separates in the crystalline form, and the process has the very great commercial advantage that the coloring matter can be developed directly on the cloth. The mixture of the acid with the alkali and glucose being printed on the cloth, exposure to superheated steam develops the color fixed in the fiber.—(*Ann. Chim. Phys.*, xxi, 286, October, 1880.)

Spiller has devised a simple means of identifying the coal-tar colors, founded on the action of sulphuric acid on the dyeing material taken in conjunction with the shades produced on and the tendency to dye silk, wool, or cotton. The most striking reactions are as follows: Magdala red with sulphuric acid gives a blue-black; saffranin a grass-green, becoming indigo blue on strongly heating; chrysoïdin deep orange, turning almost to scarlet on heating; alizarin, ruby-red or maroon; eosin, golden-yellow; primrose (naphthalene yellow), first yellow then color discharged; chrysaniline, brown fluorescence; aurin, yellowish brown; atlas orange, rose-color, changing to scarlet on heating; atlas scarlet, no alteration; biebrich scarlet (R), blue-black; ditto (B), blue-green; aniline scarlet, permanent golden-yellow; indulin, slaty blue to indigo. All violets give a yellow or brownish yellow; phenyl and diphenylamine blues dark brown solutions; iodine and malachite greens bright yellow solutions, the former giving off iodine on heating; and finally citronin, which gives a pale cinnamon color or a neutral tint.—(*Nature*, xxii, 448, September, 1880.)

Schützenberger has given in an elaborate memoir the results of his investigations into the chemical character of albumen based on the observation that when subjected, under suitable conditions, to the action of baryta water it breaks up entirely, or almost entirely, into definite crystallizable principles. His results show that the mixture of fixed principles derived from albumen by hydration contains only amido-derivatives, and that these may be divided into two unequal portions; one, about 16 or 18 per cent., containing substances in which the nitrogen ratio is 1:3, 1:4 or 2:5, mostly acids; and a second, four-fifths of the residue, represented by the formula $(C_nH_{2n}N_2O_4)_x$, the value for n being a little less than nine. Albumen is therefore probably an imido-derivative, which changes by hydration into a mixture of amido-derivatives.—(*Ann. Chim. Phys.*, V, xvi, 289, March, 1879; *J. Chem. Soc.*, xxxvi, 546, July, 1879.)

MINERALOGY.

By George W. Hawes, Ph. D.,
Curator in the National Museum.

It is unnecessary to state that in the past two years numerous contributions have been made to our knowledge of the constituents of the earth, for mineralogical study excites interest upon so many sides, and is demanded for so many economic as well as scientific purposes, that the number of workers in this department is always sure to be large. But it is of peculiar interest to note the number and the character of the investigations which have been made in this country, and the attention which they have excited at home and abroad. In looking over the list of new species it will be seen that many of the most interesting have been found here. This is not strange, considering the rapid development of our mining industries and the explorations that have been made in unknown territories. But the finding of new minerals is not at present the highest of mineralogical accomplishments, and a new name is a burden and not an aid to science. A very different thing is such study devoted to a new species as puts us in possession of new information; and it is to the character of the new species and to the study devoted to them that the prominence of American work during this period is due.

We will therefore first consider the new discoveries that are purely American, and then we will return to more general considerations.

AMERICAN PROGRESS.

Prof. E. S. Dana, in preparing a previous record of mineralogical progress, modestly refrained from assigning a prominent position to the results of the explorations in Branchville, yet it may safely be said that so fruitful a locality has for many years not been found in any land. Up to the beginning of 1879 they had extracted five new species, but since that time they have found two additional manganese phosphates, making seven in all, and also a new and interesting lithium aluminum silicate. In addition, many rare though previously described minerals have been there found by them, and much interesting analytical work has been done upon this material by Messrs. Penfield and Comstock. These analyses have also suggested investigations that have resulted in a more certain determination of the formulæ of several species and to the discovery of very interesting varieties of old ones. Mr. Comstock analyzed the tantalite, which occurs at Branchville, together with immense crystals of the rare columbite, and also analyzed and fixed the formula of uraninite, which before had never been found in such fine and fresh crystals, and of which, therefore, no material so suitable for analysis had been found. Mr. Penfield reached also as interesting results in his analyses of triphyllite and amblygonite, and also analyzed a novel variety of apatite which was found to contain a large amount of manganese. Profs. Brush and Dana have once more demonstrated the economic value of scientific industry. Their new minerals were found in a very coarse-grained vein of pegmatite. They also found there immense crystals of potash feldspar of the variety microcline, also masses of clear, pure quartz. Having extracted many tons of these materials as waste products in their search for the rare minerals, they took occasion to call the attention of a porcelain manufacturer to it, and he found on trial that the feldspar was eminently suited for the manufacture of his wares, as was also the quartz. He therefore purchased the property, and these materials have been systematically and extensively extracted ever since.

Profs. Brush and Dana have made another most important discovery, fully equal in interest to their discovery of new species, since by means of it they have perfected our knowledge of a species previously little understood. The calcium borosilicate danburite was discovered many years ago by Prof. C. U. Shepard, though its chemical composition was subsequently first correctly determined by Profs. J. L. Smith and Brush. Yet so small and imperfect were the grains then found that its mode of crystallization was never known, or at least its form could not be correctly determined. It was thought to be triclinic. Through the discovery of these gentlemen all the cabinets of the world are, or will be, enriched with large and beautifully crystallized specimens of this heretofore rare and insignificant species. The new locality is in Russell, New York, where danburite occurs in large, compact, rock-like masses and fine crystals of perfect form. The little crystals are white and transparent, and the large ones are also very perfectly formed. They are rhombic in form, and, what is most remarkable, although it possesses no apparent chemical affinity with topaz, its crystals are so deceptively like it that no one would hesitate to pronounce it topaz from its outward appearance. This resemblance extends yet further; its axes are very nearly identical in length, and its optical properties are nearly the same as in topaz. Other cases of close resemblance in form between unrelated chemical compounds are known. Calcite resembles soda nitre, for example, and aragonite resembles saltpeter. Such resemblances of the present time can only be explained as being the accidental resemblances, like those of faces in a crowd. But the fact that this borosilicate resembles topaz even in the minute details of arrangement of its crystalline planes, indicates that we have perhaps much yet to learn concerning isomorphism.

One of the most interesting studies of this period has been made upon the lithium aluminum silicate spodumene and the products of its alterations. Mr. Alexis A. Julien, of Columbia College, first examined the specimens that he obtained in Massachusetts. Spodumene, by the action of decomposing reagents in nature, exchanges its lithia for potash or soda, and becomes altered into a variety of substances, one of the most characteristic of which has been called cymatolite. Mr. Julien analyzed this substance and endeavored to fix its composition. But at Branchville, Profs. Brush and Dana found immense crystals which were originally all of spodumene, and which had decomposed in such a way as to enable them to make a most interesting investigation and arrive at new results. These crystals were of very great dimensions, some being over four feet long and a foot wide. Their interiors were still of a beautiful clear pink spodumene, but they were mostly altered into mica, albite, cymatolite, and a translucent substance which they provisionally called β spodumene. By chemical and microscopic study they demonstrated that this so-called cymatolite was composed of a very intimate mixture of white mica and albite, and that the β spodumene was composed of albite and a new mineral, which they have called eucryptite, and which will be found described beyond. The study of such processes of alteration is very important, since it develops facts of geological importance, and the changes which this spodumene has undergone form an interesting chapter in the history of pseudomorphs.

Mr. Harrington, of Montreal, has made an important study of the apatites and their associated minerals in Canada. As is well known, very large deposits of clear green and otherwise colored apatite occur there from which very large quantities are annually taken to be crushed and manufactured into superphosphates for agricultural purposes. Such deposits also occur in Norway, where they have been studied by Professors Brögger and Reusch, who determined them to be of eruptive origin. Professor Harrington, after showing that they occur in rocks of a similar nature, though unlike in detail, shows that there is abundant reason for considering that they are not eruptive rocks, and thinks that they were gathered by and crystallized from solutions. I will recall in this connection that M. Daubrée made apatite in a closed tube, by causing a volatile phosphorous compound to act upon hot limestone, and he thinks that some such deposits may have been formed by sublimation. The opinion of Dr. Harrington is sustained by the previously-formed opinion of Dr. Hunt, and it will be seen that every possible mode of origin has to-day weighty opinion in its favor. But argument of such questions is progress, and is a long step toward conclusion, and these studies have contributed much to our knowledge of these deposits. Mr. Harrington describes immense crystals of apatite a foot or more in diameter and several feet long. Mr. Adams and Mr. Hofmann have also been busy analyzing Canadian minerals. Very interesting are the analyses of scapolites by Mr. Adams. He found them all to contain chlorine, the overlooking of which was probably the cause of the evident errors of previous analyses.

The relationship in which hornblende and pyroxene stand to each other has always been a favorite subject. Although each species has numerous varieties of very variable composition, each possesses the same chemical varieties, and they are therefore considered as dimorphous. Moreover there is a very definite relationship between their forms, since doubling the length of one axis in pyroxene gives the axes of hornblende. Another feature that has attracted much interest is that pyroxene tends to alter its own internal molecular structure into that of hornblende. This results in giving us quite perfect crystals apparently pyroxene, but which possess the cleavage and optical properties of the allied species. Since the two species may be identical in composition, this has usually been spoken of as a case of paramorphism, of which we have some other illustrations. Calcium carbonate crystallized as aragonite can, for example, be internally altered to calcite, which change involves no chemical alteration. But Mr. Harrington among the apatite deposits has succeeded in finding pyroxene crystals in which this process of alteration was in progress, and in some cases had progressed to that extent that the crystals were internally pyroxene and externally of hornblende. Analyses of the materials in all cases showed that a chemical change *had* taken place, which was largely expressed in a loss of lime. In other words, the pyroxene was changed, not into a hornblende of a like composition, but a hornblende of different composition. Pyroxene crystals altered into hornblende have been called úralite, because first brought from the Urals by Gustav Rose. Professor Harrington's analyses demonstrate that his crystals are to be considered as pseudomorphs, and not as paramorphs.

Mr. Hidden has been seeking minerals in the Southern States. Among others he has found some very beautiful, transparent, green crystals of spodumene, which are a novelty and an interesting addition to the varieties of this species. Some immense crystals of sphene, weighing fifty pounds or more, have been brought from Renfrew, in Canada. Dr. Shepard has bought the celebrated Graves Mountain, Georgia, and has mined from it great numbers of very large and very beautiful rutile crystals; and the shelves of the mineral dealers will be found enriched with a great deal of material from new localities that have been developed during the past two years.

Meteorites.—When one remembers how very few are the meteorites that have been seen to fall and have then been found, and the general and keen interest felt by the whole scientific world in these celestial bodies, the very remarkable fall of meteorites that took place in our country last year must be considered as an important event. Most of the meteorites thus far found possess thoroughly individual characteristics; therefore each new discovery of a meteorite is met with the expectation of some new information regarding the composition and history of other worlds than ours. This new meteorite was thoroughly unique in its general character and brought to us a mineral which was heretofore unknown.

In Emmett County, Iowa, on the 10th of May, 1879, at five o'clock in the afternoon, although the sun was still shining and the day clear, a large meteorite was seen to pass across the sky. One person saw it at a distance of one hundred miles from the place of its fall. It is said to have made a noise "terrible and indescribable," which was louder than that of artillery, and which frightened the cattle as much as the people. One piece, five hundred pounds in weight, struck the earth at such a velocity that it buried itself fourteen feet in a stiff clay soil. A second piece, weighing one hundred and seventy pounds, and a third, weighing one hundred and forty pounds, were found in the neighborhood. Moreover, the prairie far and near was scattered with little pieces, hundreds of which were gathered. One remembers in this connection the multitude of little meteorites which fell at Pultusk, one or more of which are in every collection. The largest of the pieces of this Emmett County meteorite was sold for a great sum to the British Museum;* the second piece remained in the Iowa University collection, and the third was purchased by Yale College. The circumstances of the fall of this meteorite were first described by Professor Peckham, and Dr. J. Lawrence Smith afterward submitted it to careful investigation in the laboratory, and found it to contain a new magnesium iron silicate, which he named Peckhamite. The other constituents were chiefly metallic iron and olivine, which are common constituents of meteorites, but this meteorite was characterized by the great size of its olivine grains. It is partly on account of such large crystals that it is commonly believed that these meteorites once formed parts of greater bodies, from which they have been broken. The history of Biela's comet will be remembered in this connection, which on one of its periodic appearances was found to have divided, and which subsequently finally disappeared from the sky, though a meteoric shower occurred at about the time that it should have appeared.

Mr. Hidden has also found some interesting meteoric irons in the South. One of these was plowed out of the ground in Cleburne County, Alabama, in 1873. Though the circumstance of its being metallic iron excited the curiosity of the people, no one considered it as anything of value. A piece of it was forged into a tool, and the rest lay for years in the blacksmith shop, unknown and unappreciated. It has now been investigated by Dr. J. Lawrence Smith, who has done so much in the chemical study of these bodies.

Another block of meteoric iron weighing 120 pounds has been found at Ivanpah, Cal., by Mr. S. Goddard. It has been partially described by Prof. C. U. Shepard, and is in the possession of Mr. Hanks, the State geologist of California.

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* We should have a fund to keep such interesting things in this country.

It is known that etched surfaces of meteoric irons exhibit definite figures resultant from the crystallization of the iron, and which not appearing upon surfaces of common iron have been considered as characteristic of meteoric iron. Mr. Daubreé, and afterward Meunier, succeeded in obtaining such figures on nickeliferous iron, and now Dr. J. Lawrence Smith has succeeded in inducing like figures upon polished surfaces of iron containing silicon. Add to this the circumstance that the same happens when the Ovifak iron, which is now generally admitted to be terrestrial, is treated, and it can scarcely be claimed any longer that these figures are alone characteristic of meteoric irons.

NEW MINERALS.

We will now refer briefly to the new minerals that have been described. We think it will be seen that, if a few minerals should be struck from this list, this portion might be left out of a report upon progress, for many of these new minerals are described more for the zeal for naming than for any information of interest that their study has developed.

Abriachantite.—An impure, bluish clay, like mineral, named by Heddle after the locality where it is found in Scotland. A name given to a poorly identified species.

Animikite.—A very basic silver antimonide found by H. Wurtz at Silver Islet, in Lake Superior. Its name is derived from animikie, which means thunder; whence Thunder Bay derives its name. It is not established as a species.

Bernardinite.—A new mineral resin found by J. M. Stillman, in San Bernardino County, California. It is white in color, and so porous and light that it will float on water. A new resin has also been described by C. Dölter in the communications of the Steinmark natural history society. It was found by him in the tertiary lignites.

Bhreckite.—A substance found by Heddle at Ben Bhreck, in Sutherland, Scotland. A calcareous chlorite like mineral of undetermined composition. Named on account of the possibility that it might prove new.

Eggonite.—Probably a cadmium silicate, which is found in minute light brown crystals on calamine at Altenberg, near Aix-la-Chapelle. It was described by Schrauf, who determined it to be triclinic, but he did not definitely decide its composition.

Elenorite.—An hydrous iron phosphate, found by A. Nies in the Elœnore mine, near Giessen. It is rhombic, dark brown, translucent, and vitreous in luster. Its investigation is, however, still incomplete.

Eucryptite.—A lithium aluminum silicate, discovered by Brush and Dana, at Branchville, Conn. It is intimately intermingled with albite, forming what they call β spodumene. The two minerals are arranged with reference to one another as are quartz and feldspar in schrift granite, and, as in this case the mineral intermingled with the feldspar is hexagonal. In composition it is somewhat related to muscovite or nephelin. It is white and fibrous, and only detected by microscopic examination. Named from εὖ, well, and κρυπτὸς, concealed.

Euralite.—A dark-green chloritic substance, resembling delessite, and found by F. J. Wük, at Eura Kirchspiel, Finland.

Fairfieldite.—An hydrous manganese calcium phosphate, found by Brush and Dana, at Branchville, in Fairfield County, Connecticut. It is a colorless and transparent mineral with a good cleavage, and triclinic in crystallization.

Fillowite.—A mineral found by Brush and Dana at Branchville, and named after the owner of the property on whose land they explored. Occurs in granular and crystalline grains, the latter looking like rhombohedrons but really monoclinic in form. It is a manganese phosphate containing a little iron and soda, and of a wax-yellow color.

Fredricite.—A mineral related to tetrahedrite, but contains lead and tin. It is found in massive, iron-black pieces, at the Faln mine, Sweden, and is chiefly composed of copper, sulphur, and arsenic. Described by Hj. Sjögren.

Gelatinous chabazite.—Renevier found a gelatinous substance in fissures in the conglomerate near Lausanne, Switzerland, that had the composition of chabazite. He called it a mineral in embryonic condition. This was inappropriate, because no such condition is possible in the organic kingdom. A mineral is complete as soon as formed, and its crystalline condition is one of its essential properties. This is a new mineral if its composition is definite.

Guejarite.—A copper antimony sulphide, found by M. E. Cumenge in a vein of spathic iron, at Guejar, in the Spanish Sierra Nevadas. Occurs in bright crystalline plates, that are sometimes quite large. It is quite heavy, is steel-gray in color, and of rhombic crystallization.

Hannayite.—A hydrous magnesium ammonium phosphate found in the guano beds at Victoria. It was determined and named by vom Rath, and found to be triclinic in crystallization.

Haughtonite.—A black mica, which was taken out of gneiss from Roneval, and analyzed by Heddle. It is intermediate between biotite and lepidomelane, and consequently scarcely needs any new name.

Heldburgite.—Another mineral of unknown composition, but possessing angles like those of Zircon. It is a yellow mineral seen in the feldspar of phonolite from Heldburg in Colburg, by O. Luedecke.

Herrengrundite.—A basic copper sulphate from Herrengrund, Hungary. Occurs in six-sided tabular crystals of the monoclinic system. In color it is dark emerald green. Occurs mixed with gypsum, malachite, and calcite. (See *urvölgyrite.*)

Hofmannite.—A colorless, tasteless hydrocarbon, found in tabular crystals on lignite. Described by Bechi.

Huntilite.—A mineral named by Henry Wurtz after Dr. T. Sterry Hunt. It is a basic silver arsenide, but poorly determined. Found at Silver Islet, Lake Superior.

Köflachite.—This is a kind of mineral pitch or resin, found by C. Doelter near Köflach. The author names it with doubt, and says it is very near Jaulingite, another resin found at the same place.

Leucomanganite.—A foliated, radiated, snow-white mineral, composed of manganese and iron protoxides, alkali, and water in unknown proportions. Named by Sandberger.

Lintonite.—An hydrous calcium aluminum sodium silicate, closely allied, perhaps, identical, with thompsonite, which was found in amygdaloidal cavities in diabase near Grand Marias, Cook County, Minnesota. Named after Miss Laura Linton, the analyst of the specimens.

Louisite.—A leek-green translucent vitreous brittle mineral found by D. Honeyman, at Blomidon, Nova Scotia, and named from the princess, It is an hydrous lime potash silicate.

Luckite.—An hydrous manganese iron sulphate, found with mallardite in the Luckyboy silver mine, Butterfield Cañon, Utah. It is clear. with a bluish tint; found in indistinct striated prisms in a black bituminous rock, isomorphous with melanterite, from which it differs in the presence of manganese. Described by A. Carnot.

Mallardite.—An hydrous manganese sulphate, soluble in water, described by A. Carnot, from the Luckyboy silver mine, Butterfield Cañon, Utah. It occurs in colorless fibrous crystals in a gray clay like stone, together with quartz and barite.

Mixite.—A copper bismuth arsenate containing water. It is found as an emerald or bluish-green incrustation on bismuth ochre. It forms spherical and reniform aggregations, and granular irregular particles. Found in the Joachimsthal, and determined by A. Schrauf.

Newberyite.—Another mineral found by vom Rath in the Victoria guano beds; it is a magnesium phosphate containing water, and orthorhombic in crystallization.

Ontariolite.—An "embryonic" mineral, named before its investigation by Prof. C. U. Shepard. It is a member of the scapolite family, found at Ottawa, Canada.

Orizite.—A mineral of the composition of heulandite found in the tourmaline granite at San Piero in Campo, by Grattarola. It occurs in crystals, and crystalline grains of the color and luster of rice kernels.

Peckhamite.—A magnesium iron silicate found by Dr. J. Lawrence Smith in the meteorite that fell in Emmet County, Iowa. It is dingy-yellow in color, has a perfect cleavage, and occurs in nodules several millimeters in diameter. It is intermediate between olivine and bronzite. Named after Professor Peckham, who first described the fall of this remarkable meteorite (see *Meteorites*).

Philadelphite.—A mineral found in a decomposing hornblendic gneiss on Germantown Avenue, Philadelphia. In composition and properties related to vermiculite. A pearly micaceous mineral, which exfoliates when heated to ten times its original volume. Described by Henry C. Lewis, of Philadelphia.

Phosphuranylite.—A pulverulent incrustation found on quartz and feldspar, of a pearly luster, and lemon-yellow color, and determined by F. A. Genth to be a hydrous uranium phosphate.

Picite.—A hydrous iron phosphate which like the Elenorite, before mentioned, is found in a mine near Giessen. It is amorphous dark brown translucent, and has a fatty luster. It occurs in little stalactites, and spherical concretions, or in coats on other minerals.

Plagiocitrite Klinophæite and Wattevillite, are some hydrous sulphates found by S. Singer on the Bauersberg near Bischofsheim, on the Rhone. They resulted from reactions between the decomposing pyrites in some lignite beds, and an underlying basalt, or the tuff mixed with the lignite. They remain to be further investigated.

Pseudonatrolite.—A new zeolite described by Grattarola from San Piero in Campo. It is found in minute colorless crystals with a glassy pearly luster, and probably orthorhombic in crystallization. It is a calcium aluminum silicate, and named from its relation to natrolite.

Randite.—A lemon-yellow incrustation found on granite and determined to be a calcium uranium carbonate, near liebigite in composition. Named for T. D. Rand of Philadelphia by G. A. Koenig.

Reinite.—A pure iron tungstate, discovered by Professor Rein in Kimbosan, Japan, and investigated by K. von Fritsch and Luedecke. It is a black-brown opaque substance; found in large square crystals assumed by analogy to be monoclinic.

Thaumasite.—A white translucent mineral, from Aareskutan, described by G. Lindstrom, with fatty glance, and choncoidal fracture. It is an hydrous lime carbonate, sulphate, and silicate. One would think it a mixture, but several analyses exactly agree, and Törnebohm, a careful analyst, is assured that it is no mixture. One will remember cancrinite, which is a silicate and carbonate. This mineral is justly named from *ϑαυμαζω*, to wonder.

Titanomorphite.—The gray translucent substance which is so very frequently found in microscopic sections of rocks as a decomposition product of titanic iron and rutile, has been the subject of much discussion. It has never been found practical to separate it and analyze it, hence its composition has always been a subject of speculation; von Lasaulx found masses in an amphibolite, from Hohe Eule, of sufficient size to analyze. He fixed its composition as a calcium titanate, identical with perowskite. The substance previously had two or three names, and was best known as leucoxene, a name given by Gümbel. It was scarcely necessary to give it another.

Trippkeite.—A copper arsenite from Chili, the composition of which was determined by A. Damour, and the crystallographic properties by G. vom Rath. It is a quadratic mineral, the optical proof of which was furnished by Des Cloizeaux. It was named for Dr. Paul Tripkie, a mineralogist in Bonn, who was unfortunately killed shortly after he had found this mineral, which he suspected to be new.

Tysonite.—A mineral found by Messrs. Tyson and Wood, on Pike's Peak. It was found by Prof. O. D. Allen and Mr. W. J. Comstock to be a fluoride of the rare earths cerium lanthanum and didymium. It is a hexagonal mineral of vitreous and wax-yellow color, and very heavy. It was named from the finder.

Urisite.—An hydrous iron sulphate, containing soda, described by A. Frenzel. It has a citron or pomegranate yellow color, and occurs in rhombic crystals. It was obtained in the Caucasus.

Urvölgyite.—This is the same thing as the Herrengrundite described by Brezina. This name was given by Szabo, but the lime which Brezina found resulted from an intermixture of gypsum, Szabo considered to be an essential constituent.

Xantholite.—Another of Heddle's possibly new minerals. Found at Loch Ness, Scotland. Like grenatite, but of different color. A poorly determined species.

IMPORTANT STUDIES.

It will be noticed that many of the new studies have consisted in the continued application of the later-developed optical methods to previously-determined species. This is because the ideas which constitute a crystal have been changed, thus necessitating a reinvestigation of all minerals. One sees no more in the new text books that a crystal is a body bounded by planes symmetrically arranged by forces of crystallization. But a crystal is a body with a defined molecular structure, possessing like elasticity in like directions. The planes which may or may not bound such a substance are simply one of the features of this molecular structure, in the same way as are the optical, electric, magnetic, thermal, and other properties. The isometric crystalline form of a substance can be more perfectly established by the examination of a pair of sections from an irregular fragment than from the outer form of a developed geometrical form. Opaque substances only are investigated in the same way as of old, and even these can be studied by thermal methods. The degree of symmetry in crystals are considered as the prominent features in geometrical study, and the crystalline axes, such as are not assumed for simple convenience of calculation, are the normals to these planes, and not imaginery lines. These principles, which have much simplified the science in some directions and complicated it in others, are not new developments, but progress worthy of note has been made in the more general acceptation of the new system and its introduction into elementary instruction.

Feldspar.—The study of the chemical relationships of the feldspars has deeply interested mineralogists for several years. It will be recalled that Tschermak, by a laborious investigation, attempted to systematize all those kinds of feldspar of intermediate content of silica by a theory of isomorphism of the extreme members of the group. This theory was prevented from receiving general acceptation by the researches of Des Cloizeaux, who gave definite optical properties for the oligoclase and labradorite as well as the rest. But now Schuster, by a more extended series of investigations, has been convinced that in optical as well as other properties, all these intermediate species do form a regularly progressive series, such as might be expected to result from isomorphous combinations. Many speculations have been made with the view of explaining how a lime alumina silicate like anorthite can be isomorphous with potash or soda alumina silicates, which, like albite and microcline, are of entirely different atomic ratio. The satisfactory understanding of this is a thing to be determined when knowledge is further advanced. The fact of the isomorphism is admitted, and the theory of the isomorphous replacements to form intermediate feldspar species has gained ground.

The dimorphism of potash feldspar has been known for some time. But it has proved to be quite surprising to find that the new species microcline is on the whole much more abundant than the old species orthoclase, which previously embraced the whole. Microcline differs but extremely little in geometrical form from orthoclase, but its optical properties are very markedly different. It is composed of a series of laminæ most intricately interwoven, a result of twinning according to two different systems. Now Levy has lately shown that if this system of twinning, which is sometimes carried to such an extent that the individual laminæ become minutely microscopic, were only repeated still further, and the laminæ subdivided until even the microscope could not detect them, such a microcline would have all the properties, optical and otherwise, of orthoclase. In this he is supported by able French mineralogists, and it would appear as if we were liable to lose the old classic orthoclase altogether.

Other studies of twins.—A twinning plane becomes of necessity a plane of symmetry, and thus by simple repetition of this process very regular bodies result from the least symmetrical. The process of reducing well-known minerals to less symmetrical systems has gone on as vigorously as heretofore. For example, chabazite, which was considered as a most typical rhombohedral mineral, has been shown by Becke to receive its usual form by the repeated twinning of its triclinic crystals. Leucite, which at the time of the last review had with general consent been reduced from the isometric to the quadratic system, has since been found by Websky to be orthorhombic, and by others has been considered as still less symmetrical. Perowskite and Boracite receive their apparent isometric forms by the repeated twinning of rhombic crystals. Other examples might be given, but these are sufficient to show what is being done in these directions. The results of such studies, if of interest in detail to but few (and they are treated with utmost detail), must not be underestimated, for they tend toward a better understanding of molecular structure, a knowledge of which may at any time prove of utmost interest to all.

Mica.—Prof. G. Tschermak, who, as is well known, has made a most valuable investigation upon micas, the results of which proved that all micas are monoclinic in form and that they possess variable optical properties which necessitated a redivision and to a certain extent a new nomenclature, has now, with the aid of Sepöcz, extended his examination to the brittle micas of the clintonite group. These he finds also to be monoclinic, and possessed of optical properties that make it possible to systematize them in the same way as the elastic micas. Thus our knowledge of a large number of minerals which before were very imperfectly understood has been much improved.

ARTIFICIAL MINERALS.

The synthetic methods of study have always found especial favor in France. The impetus given by the men who have so distinguished themselves in this way has in the past year brought forward a number of new studies, almost all of them French.

Daubrée's new book upon experimental geology contains an account of all his previous experiments, and noticeable are the methods that he has used to make sublimed minerals. The book is very interesting to read, though its chief merit is the bringing together in condensed and accessible form all the distributed writings of the author upon these subjects.

Fouqué, who some time since succeeded in reproducing the feldspars by the simple process of allowing fused mixtures to slowly cool, has by the same process made leucite, nephelin, and a variety of rocks that are composed of minerals arranged in the same way, and scarcely distinguishable from volcanic products. These results both have a geological interest, and are noticed in that section.

Fouqué and Levy performed the very pretty experiment of fusing a mixture of scapolite and hornblende, and obtained by slow cooling a mixture of labradorite and pyroxene. One recalls the old experiment of Mitscherlich, who fifty years ago fused hornblende and obtained pyroxene. One of the very interesting experiments of Fouqué and Levy recently performed was that by which they produced feldspars of various degrees of acidity, in which lead, baryta, or strontia were made to take the place of the bases ordinarily found in them.

Velain has examined microscopically the fused ashes of grasses and other plants, and found in them tridymite, anorthite, wollastonite, and augite. Professor Maskelyn has described an artificial diopside rock formed in a Bessemer steel converter. Liebethenite, the copper phosphate, has been found to be very easily made by Friedel and Sarasin. Scorodite, the iron arsenate, has been made by Verneuil and Bourgeois. Hautefeuille has made leucite, also an iron leucite, that is one which contains iron sesquioxide instead of the usual alumina. Meunier has made enstatite, spinel, and corundum. This does not cover the whole list, but it is sufficient to show the energy with which the synthetic method is being pursued in France.

Some very interesting experiments have been tried in the way of producing artificially some of the physical features of minerals. Calcite has been noticed to be usually in the condition of polysynthetic twins when in ordinary limestones, and it has been found that this twinned structure can be induced in a simple crystal by pressing it in certain directions. Baumhauer has shown how to make a perfect artificial twin yet more simply. He takes his jackknife and presses its edge perpendicularly into the pole edge of a rhomb near its apex. The parts displaced by the jackknife then assume a position with reference to the undisturbed parts as would a rhombohedron twinned with the next more obtuse rhombohedral plane as twinning plane. One can thus easily get a symmetrically formed twin with its re-entrant angle exactly like the calculated angle of the twin. This is a beautiful little experiment that any one can try in a moment for himself, but to understand its full import and bearing is a deep problem.

Archæological Mineralogy.—Under the title of "Nephrite and Jadeite," Prof. Heinrich Fischer has issued a volume which is the second that he has devoted to a description of the results of his studies upon these and other minerals, which in prehistoric times were cut into ornaments, amulets, stone axes, &c. He has thus in a systematic manner introduced the study of mineralogy into archæology. With the aid of the microscope and all available scientific resources, he has endeavored to find the nature of the stones most prized by the ancients. His long-continued studies show him that for an insufficiently understood reason, they had a decided preference for green stones, which they brought from most distant lands. The stones mostly obtained and modelled were: green limestones, apatite, green quartz and serpentine, mica-schist, chlorite schists, amazon stone (green feldspar), idocrase epidote, hornblende, and pyroxyne; and particularly in Asia and New Zealand, the very tough and hard nephrite and jadeite. It will never cease to be a wonder how the ancients so beautifully cut and polished these hard stones with their poor contrivances, and the archæologists will be thankful to this eminent mineralogist who has so carefully determined the mineral nature of so many of their objects of interest, and systematized a great mass of their previously uninteresting material.

Other extensive works.—The fourteenth communication of Mr. W. G. Hankel on the electric properties of minerals has already appeared. He has demonstrated that all minerals possess poles and electric properties of one kind or another, and that the distribution of the electricity over the crystals is variable. He has not been able to deduce from his studies any very complete system, and the results are therefore rather wearisome in their details.

The optical properties of isomorphous mixtures have been studied by Wyrouboff, and Mr. C. Dölter has digested all the analyses of the minerals of the pyroxene family, and also studied their physical characters. As a result he has given a classification of the varieties of this mineral, which contains some improvements.

Mr. E. Mallard has issued the first volume of his treatise on geometrical and physical crystallography, accompanied by an atlas of nine plates. The completed work is to cover the field of mineralogy, and is of much importance, since no very extensive general treatise on mineralogy has appeared in France since the time of Hauy.

Prof. J. Reinhard Blum, in his old age, has added a fourth supplement to his work upon pseudomorphs. The better part of his life may be said to have been devoted to this study. His work has become one of the classics of mineralogy, and has had much influence in geology. He evidently intends that so long as he lives his work shall be kept abreast of the times. If he is not longer able to take part in the active hard work that is being devoted to this subject, his new supplement shows that nothing of importance escapes his attention or overtasks his memory.

BOTANY.

By Prof. William G. Farlow.

PROGRESS IN 1879.

During the year 1879 publications on botany have been numerous in all departments of the science, especially on the subjects of cryptogamic botany and vegetable physiology, but the number of works of large extent and those which the Germans would describe as epoch-making is comparatively small. The activity of the botanical world during the year is shown, however, by the large numbers of papers containing either the results of observations on detailed subjects in vegetable anatomy and morphology, or in descriptions of new species, both of phænogams and cryptogams. The proportion of valuable papers relating to the effects of light on plants, to the physiological relations of the different coloring matters, and to the action of the different forms of ferment is also to be noticed.

GENERAL.

The *Chronological History of Plants*, or man's record of his own existence, illustrated through their names, uses, and companionship, is a quarto of over 1200 pages by the late Charles Pickering. It is an immense collection of scattered facts about different common and cultivated plants, and the press-work is extraordinarily well done. *Gray's Botanical Text-Book*, Part I, Structural Botany, now appears as one of a series of three volumes, of which the second and third volumes are to be devoted respectively to physiological botany and cryptogamic botany. The part which has already appeared is modeled on the author's well-known Structural and Systematic Botany, but with much additional matter. The first part of Luerssen's *Handbuch der Systematischen Botanik*, intended especially for the use of medical students and apothecaries, is devoted to cryptogams, and both text and plates are excellent. The *Handbuch der Botanik*, by Schenk, which forms a part of the *Encyclopædie der Naturwissenschaften* appeared in part in 1879, and contained articles by Hermann Müller on the Relations between Flowers and their Crossing by means of Insects, and by Drude on Insectivorous Plants.

VEGETABLE ANATOMY AND PHYSIOLOGY.

An important paper by Pringsheim on the Action of Light and the Function of Chlorophyl was communicated to the Berlin Academy in July of this year. The paper is in the nature of a somewhat lengthy preliminary communication which the writer intends to give in full with illustrations in his Jahrbücher. Pringsheim reports the discovery of a substance, to which he gives the name of *Hypochlorin* or *Hypochromyl*, which is obtained from chlorophyl-bearing tissues by allowing them to remain in dilute hydrochloric acid for several hours. The Hypochlorin then appears in the form of small, viscid drops or masses of semi-fluid consistency, which ultimately are transformed into long, reddish-brown, indistinctly crystalline needles. According to Pringsheim, he has proved that chlorophyl, by its power of regulating plant-respiration in light by means of its absorption of the most active chemical rays, depresses the amount of respiration in green plants exposed to the light below the amount of assimilation, and so makes possible the accumulation of carbon-products and the persistence of the plant in the light. Hoppe-Seyler has discovered a substance to which he gives the name of Chlorophyllan, which has the form of dark green, velvety-looking plates, which are curved and often united in rosettes. Gautier, in the Comptes Rendus, regards the chlorophyllan of Hoppe-Seyler as crystallized chlorophyl itself, and he claims for himself the priority of its discovery. The *Heliotropic Phenomena of Plants* is the title of a monograph by Wiesner, first presented to the Vienna Academy in 1878, but not generally made public until the present year.

The Annales des Sciences contain an article by Bonnier on nectaries, and a copiously illustrated paper by Vesque, *Sur le Sac Embryonnaire*, in which he supports the views of Warming as to the signification of the embryo-sac, rather than the views of Strasburger. L. Koch, in his monograph of the *Development of the Crassulaceæ*, gives a large number of finely drawn plates of the microscopic structure of species of that order. The mode of fertilization in *Zostera marina* has been studied by Engler, who criticises unfavorably the views on the subject formerly held by Hofmeister.

The American Naturalist contains a number of short papers on fertilization, among which may be mentioned: *Certain Contrivances for Cross-fertilization in Flowers*, by Prof. J. E. Todd; *On the Fertilization of several species of Lobelia*, by William Trelease; *The Fertilization of our native species of Clitoria and Centrosema*, also by Trelease; and *On the Fertilization of Yucca*, by Thomas Meehan, a paper read before the Am. Ass. for the Advanc. Science. In the Botanical Gazette are papers on *Trimorphism in Lithospermum canescens*, by E. F. Smith, and on *Sexual differentiation in Epigæa repens*, by L. F. Ward, and a note on the movement of the stamens of *Sabbatia angularis*, by the same author. In the Am. Journ. Science Prof. W. J. Beal describes his *Experiments in Cross-breed-*

ing plants of the same variety, his conclusion being that the crossing is highly favorable.

DISEASES OF PLANTS.

The coffee-leaf disease produced by *Hemileia vastatrix* is described and illustrated in an article by R. Abbay in the Journ. Linn. Soc. In *Fungi Pomicoli*, Von Thuemen gives a summary of the fungi which attack the common fruit trees. A disease attacking seedling beech plants; supposed to be caused by *Phytophthora Fagi*, and the distortions of spruces produced by *Nectria cucurbitula* are described by Hartig in the Forstwiss. Centralblatt. Reinke and Berthold describe the manner in which potatoes are decomposed by the action of fungi in the proceedings of the botanical laboratory in Göttingen, and Thomas describes a large number of galls produced in plants by different insects, in the Zeitschrift für die gesammten Naturwissenschaften. A general treatise on *Diseases of cultivated plants produced by Fungi* by Winter has appeared from the press of Scholze, in Leipsic. The appearance in France of the onion smut, *Urocystis Cepulœ*, well known in some parts of the United States, has been recorded by Cornu, and the same botanist published several communications on the disease of the vine known as anthracose, or, as it is frequently called, anthrachnose. Planchon and Cornu do not agree with regard to the fungus producing the disease in question, the former thinking the fungus to be *Sphaceloma ampelinum* De Bary, and the latter, *Phoma uvicola* Berk. and Curt. Under the title of *Ampelomiceti Italici*, Spegazzini has continued his account of the fungi attacking grapes in the Rivista della viticultura. In *Die Pocken des Weinstockes* Von Thuemen gives his observations on *Gleosporium ampelophagum*, a fungus which attacks grapes.

THALLOPHYTES.

Algœ.—Of papers relating to the algæ of the United States but little can be said. The Bull. Torrey Club contains some new fresh-water species by Wolle, and the Am. Naturalist contains a preliminary report by Farlow on algæ collected by Prof. A. S. Packard in the Great Salt Lake. Nor have works on algæ in foreign countries been as numerous as usual. The second part of Cohn's Kryptogamen Flora von Schlesien contains the algæ elaborated by Kirchner, and the Nuovo Giorn. Bot. Ital. contains a paper by Borzi on the *Morphology and Biology of the Phycochromaceœ.* Kjellman, in a short paper, illustrated by a chart, gives an account of the distribution of algæ by regions on the Skager-Rack. Prof. E. P. Wright has two illustrated papers in the Transactions of the Royal Irish Academy: *On the cell structure of Griffithsia setacea and on the development of its antheridia and tetraspores*, and *On the so-called Siphons and on the development of the tetraspores in Polysiphonia.* The Trans. Linn. Soc. contains an account, by D. D. Cunningham, of a curious new genus, the single species of which, *Mycoidea* *parasitica*, grows as a parasite on the leaves of the tea plant, the mango, and other plants. Zopf, in a small pamphlet, has described and figured the stages of development of *Crenothrix polyspora*, a species which causes pollution of the water at Berlin and other places.

The cause of the motion of *Oscillariæ* and Diatoms has been studied by T. W. Engelmann, who, in an article in the Botanische Zeitung, states that it is owing to the presence and contraction of a thin external layer of protoplasm. Stahl found that when desmids are exposed to the light they undergo certain peculiar motions, viz, their long diameters are in the direction of the light, the distal end of the cells being attached to the substratum, and at more or less regular periods the cells make a half revolution, so that what was the distal end becomes the forward end. Stahl also has a paper in the Botanische Zeitung, in which he shows that the genus *Vaucheria* has a resting condition which is identical with the so-called species of *Gongrosira.* Reinke, in Nova Acta Leop. Carol., has an illustrated paper on the *Cutleriaceæ of the Gult of Naples*, in which he claims to have seen the union of the antherozoids and oogonia. In the proceedings of the Niederrhein. Gesellsch. Schmitz has papers on the *Structure of the Cells in Siphonocladieæ* and on the *Formation of the Fruit in the Squamarieæ.*

Lichens.—In the department of lichenography very little was published in the United States in the present year, the only notable work being the list of lichens contributed by Professor Tuckerman to the report of Professor Rothrock, which has already been mentioned. In Europe, however, a number of descriptive papers has been published. In the Journal Linn. Soc. is an account, by Prof. T. M. Fries, of the lichens collected during the *English Polar Expedition*, 1875–'76, in which, in referring to the list of lichens collected by the Hayes Arctic Expedition and published in the Proc. Acad. Nat. Sci. of Philadelphia, he doubts the accuracy of the determinations in the case of some of the species there mentioned. The Jour. Linn. Soc. also has a paper by Crombie on Australian lichens, and the same writer has a notice of new British lichens in Grevillea. Leighton's *Lichen-Flora of Great Britain* has this year passed to a third edition. Additions to the lichen-flora of Europe have appeared in Flora and Hedwigia from Arnold and Nylander. The last-named writer has also a curious note in Flora entitled *Circa Lichenes vitricolas Notula.* In Cohn's Kryptogamen Flora von Schlesien, the second part of which appeared in 1879, the descriptive part relating to lichens was worked up by B. Stein. Inasmuch as Stein himself is a disciple of Körber, and not a follower of Schwendener, the general introduction on the nature of lichens was intrusted to Schrœter, who is a Schwendenerite.

During the year the discussion as to the nature of lichens has been carried on in the different journals, epecially in Flora and Grevillea, and the articles have mostly been written by botanists opposed to the Schwendener theory. In Grevillea is a paper by Cooke and in the Revue Mycologique one by Roumeguère, both strongly against the parasitical nature of the lichens. In Grevillea, Crombie, while in general discrediting Schwendener's views, is unwilling to accept Minks's theory with regard to microgonidia, which he believes to be merely small particles having a Brownian motion, as does also Nylander. The most extended work on the nature of lichens published this year is an illustrated octavo of about 250 pages by Minks, entitled *Das Microgonidium*, in which his well-known views are given in great detail. In the Am. Jour. of Science Professor Tuckerman, in discussing the question of the gonidia of lichens, states that he has observed microgonidium-like masses in *Parmelia tiliacea* v. *flavicans*, and in the Bibliothèque Universelle Prof. J. Müller states that he has seen microgonidia in two other species of *Parmelia*.

Fungi.—As usual an immense number of new species of fungi has been described during the year, principally in a large number of small papers scattered through the different journals. In addition to the journals, such as Grevillea, Hedwigia, and Michelia, devoted exclusively to cryptogams, there appeared this year a new journal, *Revue Mycologique*, devoted exclusively to fungi. It is a large octavo, and is published quarterly under the editorship of M. Casimir Roumeguère of Toulouse.

In the United States several important papers appeared. The thirty-first annual report of the New York State Museum of Natural History contains the report of the botanist, Mr. C. H. Peck, in which is embodied a large amount of mycological matter, including an arrangement of the *Myxomycetes* of New York according to Rostafinski's classification. A second paper, read before the Albany Institute by Mr. Peck, is on the *United States Species of Lycoperdon*. Besides these papers a number of new species of American fungi have been described in the Botanical Gazette by Peck, in Grevillea by Cooke and Ellis, and by Von Thuemen in the Bull. Torrey Club and Revue Mycologique. A Californian species, *Helvella Californica*, is described and figured by W. Philips in the Trans. Linn. Soc. In the Am. Quart. Micros. Journ. is a paper by F. B. Hines, *Observations on several forms of Saprolegnieæ*. Several works of importance have appeared in Europe. The *Mycographia* of Cooke has been continued, and the first volume brought to completion. Berkeley and Broome have described new species from Queensland in the Trans. Linn. Soc. The fourth part of Karsten's *Mycologia Fennica* has appeared, including the *Hypodermii*, *Phycomycetes*, and *Myxomycetes*, also the *Discomycetes* of Gillet's *Champignons de la France*. Oudemans has published several papers on fungi of the Netherlands in the Archives Neerlandaises, and for Scotland one must note the *Mycologia Scottica* of J. Stevenson. The Revue Mycologique contains a number of papers by Roumeguère relating to fungi new to France, as well as some entirely new species as *Rupinia Pyrenaica*. Hedwigia contains a number of notices of Swiss fungi, by Winter, especially of fungi of the order *Uredineæ*. Besides papers already enumerated, Cooke has descriptions of

British fungi and a paper on a new genus, *Peniophora*, in Grevillea. The articles by Von Thuemen are numerous and scattered in several journals, and include descriptions of species from Egypt, Siberia, Germany, and other countries.

The development of *Acidium abietinum* has been very carefully studied by De Bary, who connects it with stylosporic and final forms found on alpine species of *Rhododendron.* A nearly related form is found in Finland, on *Ledum*, according to Woronin. In a paper on the *Development of some Uredineæ* in the Beiträge zur Biologie, Schroeter gives an account of the development of a *Uredo* on *Ledum*, and a detailed account of a number of different *Pucciniæ.* Cornu has published a number of scattered notes in the Bull. Soc. France, of which may be mentioned in this connection some *Remarks on Uredineæ, especially the genus Roestelia.*

HIGHER CRYPTOGAMS AND MUSCINEÆ.

In this country the principal work published during the year has been the continuation of Eaton's *Ferns of North America.* The same writer also published in the Bull. Torr. Club a paper on *New and little-known Ferns of the United States*, the species mentioned being principally from Florida. A second illustrated work is *Fern Etchings*, by John Williamson, which contains illustrations of 68 ferns of the United States. Baker has described, in the London Journal of Botany, ferns from Borneo, the Fiji Islands, and the Sulu Archipelago.

In mosses we have a paper by Lesquereux and James in the Proc. Am. Acad. of Arts and Sciences, entitled *Descriptions of some new species of North American Mosses*, with a note by W. P. Schimper, and three papers by C. F. Austin, one on *Some New Musci*, in the Botanical Gazette, and *Bryological Notes* and *Notes on Hepaticology*, in the Bull. Torr. Club. In the last article, besides species of the United States, a number of species were described from the Sandwich Islands. Of foreign writings on mosses and hepatics, we may mention papers by Lindberg on northern liverworts and mosses, Massalongo's *Hepaticologia Veneta* in the proceedings of the Soc. Veneto-Trentina, and Hampe's *Enumeration of some Brazilian Mosses.*

Of developmental papers and those concerned with minute anatomy in this department of botany the *Untersuchungen über Lebermoose*, by Leitgeb, deserve especial notice. Of the work just named, parts four and five appeared in 1879, and treated of the *Ricceæ* and *Anthocerateæ.* The same writer also published a paper on the development of ferns in the proceedings of the Vienna Academy of Sciences. The sexual generation of the *Marrattieæ* was described and fully illustrated by Jonkmann in a pamphlet published at Utrecht. Bauke, in a study of the prothalli of *Platycerium grande*, came to the conclusion that the bilateral form of the prothalli was not owing to any inherent property, but to the action of gravity. In a short paper in Flora, Bauke also has some remarks on the prothallus of *Salvinia natans*. Goebel, in the Botanische Zeitung, mentions a peculiar formation of shoots on leaves of *Isoetes*.

In *Characeæ* we have to notice the appearance of *Characeæ Americanæ* in two fasciculi by Dr. T. F. Allen, including *Chara gymnopus* var. *elegans*, A. Br. and *C. crinita* var. *americana*, of which descriptions and colored plates are given. The proceedings of the Boston Society of Natural History contain a paper by B. D. Halsted on the *Classification and Description of the American Species of Characeæ.* The systematic position of the *Characeæ* was discussed by S. H. Vines in a paper in the Journal of Botany entitled *The Pro-embryo of Chara*, and he considers that the order forms an independent group intermediate between the *Carposporeæ* and the *Muscineæ*.

PHÆNOGAMS.

Among the descriptive works on North American plants may be mentioned *Reports upon the Botanical Collections made in portions of Nevada, Colorado, New Mexico, and Arizona* during the years 1871–'75, by J. T. Rothrock. The work forms a part of the reports on the geological surveys west of the 100th meridian made under the charge of Lieut. G. M. Wheeler, and is a large quarto, with finely executed plates by Sprague. In the elaboration of special orders and genera, Professor Rothrock was assisted by the following gentlemen: S. Watson, George Engelmann, T. C. Porter, M. S. Bebb, William Boott, George Vasey, D. C. Eaton, T. P. James, and Edward Tuckermann. The descriptive portion of the work is preceded by notes on the general character of the vegetation of Colorado and New Mexico and notes on the economical properties of a number of species. The botanical contributions of Prof. A. Gray consist of two papers published in the Proceedings of the American Academy of Arts and Sciences; *Characters of some new species of Compositæ* in the Mexican collection made by C. C. Parry and Edward Palmer, chiefly in the Province of San Luis Potosi in 1878; and *Some new North American genera, species*, &c. The new genera are *Suksdorfia*, from the Columbia River, and *Howellia*, from Oregon. In the same Proceedings are two papers by Mr. Sereno Watson: *Revision of the North American Liliaceæ* and *Description of some New Species of North American Plants.* In the last-named paper, which includes the new genus *Hollisteria*, the species described are principally from the west coast and from Florida, the greater part having been collected by Dr. E. Palmer. Besides the papers above named, there has appeared a number of shorter papers and notes in the different journals, among which may be enumerated *Notes on Baptisia*, by W. M. Canby, in the Botanical Gazette; *Notes on Vitis*, by Dr. George Engelmann, and *Ballast Plants in New York City*, by Addison Brown, in the Bulletin of the Torrey Club; *Colorado Plants*, by I. C. Martindale, in the American Naturalist; and *Catalogue of the Phænogamous and vascular Cryptogamous Plants collected in Dakota and*

Montana, by Prof. J. W. Chickering, in the Bulletin U. S. Geol. and Geog. Survey. The American Journal of Science contains a paper by Prof. C. S. Sargent on the *Forests of Central Nevada, with some remarks on those of the adjacent regions*, in which the comparative distribution of trees and shrubs in the Rocky Mountain, the Nevada, and the Sierra Nevada regions is discussed, and in the same journal is a paper by Professor Gray on the *Pertinacity and Predominance of Weeds*, in which he comes to the conclusion that "self-fertilization is neither the cause, nor a perceptible cause, of the prepotency of the European plants which are weeds in North America." In addition to the papers above enumerated are two others by foreign writers, which treat of North American plants; one by A. W. Bennett, on *Polygalæ Americanæ*, in the Journal of Botany, and one on the *Flora of the Saint Croix and Virgin Islands*, published in the Bulletin U. S. National Museum, by Baron H. F. A. Eggers.

Of the very numerous papers on local European floras nothing need be said at present. The *Conspectus Floræ Europææ*, by Nyman, of which the first fasciculus was announced in 1878, has been continued, and has for its useful object the collation of the floras of the different European countries. Of foreign works should be mentioned the second volume of Hooker's *Flora of British India* and the continuation of Boissier's *Flora Orientalis*. One of the most sumptuous works which appeared during the year was *Aroideæ Maximilianæ*, by Schott and Peyritsch, containing magnificent colored folio plates of the Aroids collected during the journey of the Emperor Maximilian I to Brazil. The Archives du Muséum contain monographs of the genera *Ligustrum* and *Syringa*, by Decaisne, and in the Proc. Bot. Soc. of Edinburgh is a monograph by Bennett of the genus *Halophila*, which enters into the microscopic structure of the species. In an elaborate paper, entitled *Methodik der Speciesbeschreibung und Rubus*, the writer, Dr. Otto Kuntze, discusses the variability of the species of that genus, and proposes a new method of nomenclature by means of symbols, a proposition which has met with very little favor from systematic botanists. Beccari, in a work issued in parts under the title of *Malesia*, has published the results of his travels in the Malayan Archipelago, and the same author in the Zeitschrift Oesterr. Vereins describes a gigantic aroid, *Amorphophallus Titanum*, from Sumatra. In this connection reference should be made to Hooker and Ball's *Marocco and the Great Atlas*, which, although not a purely botanical work, treats largely of the plants of that country. The *Flora Brasiliensis* has been continued, and in 1879 there appeared the *Gramineæ*, by Döll; *Lobeliaceæ*, by Kanitz; *Plumbagineæ* and *Plantagineæ*, by Schmidt. An important economical as well as botanical contribution is Todaro's *Account of the Cultivation of Cotton in Italy*, followed by a monograph on the genus *Gossypium*, a work published at Rome and consisting of about three hundred pages of text with twelve folio plates.

PROGRESS IN 1880.

GENERAL.

One of the important works published during the year is *La Phytographie* or the art of describing plants considered from different points of view, by A. De Candolle. Besides the instructive considerations on nomenclature and descriptions, there is given a list of principal herbaria and the authentic collections which they contain. We must also mention the *Index perfectus ad Caroli Linnaei species Plantarum*, nempe earum primam editionem, by Baron F. von Mueller. A valuable new journal has appeared during the year, the *Botanisches Centralblatt*, edited by Dr. Oscar Uhlworm, assisted by a number of specialists. It is issued weekly by Theodor Fischer, Cassel, and has for its object the presentation of short reviews and notices of botanical works and society communications as soon as possible after their publication. The journal also includes a certain number of original communications. The number of botanical text-books which has appeared during the year is rather large. We would mention first, *Botany for High Schools and Colleges*, by Prof. C. E. Bessey, which forms one of the American Science Series issued by Henry Holt & Co. The book covers all the departments of botany, and is copiously illustrated. An Historical Sketch of the Science of Botany in North America from 1840–1858, by Frederick Brendel, is finished in the American Naturalist for 1880. Of the numerous European text-books mention should be made of N. J. C. Müller's *Handbuch der Botanik*, in two volumes; Reinke's *Lehrbuch der allgemeinen Botanik;* Behrens's *Method-Lehrbuch der allgem. Botanik*, and Warming's *Den almindelige Botanik.*

VEGETABLE ANATOMY AND PHYSIOLOGY.

The structure of sieve-cells has been treated in two papers by Janczewski, and by Wilhelm. The distribution of stomata on the subterranean parts of plants has been studied by Hohnfeldt, and the Am. Naturalist contains a paper by W. K. Higby, on the *Microscopic Crystals contained in Plants.* On the subject of morphology of special plants, we may mention A. F. W. Schimper's *The Vegetative Organs of Prosopanche.* The Beiträge zur Biologie contains a paper by Klein, on the structure of *Pinguicula alpina*, an insectivorous plant. In the Proc. Royal Soc. is a paper by Vines, on the *Chemical Composition of Aleurone-grains.* The aleurone grains in *Pœonia* are completely soluble in water; in some other plants they are not. Aleurone grains are always surrounded by an insoluble membrane which contributes to the formation of the network which remains after the soluble parts have been removed. In a paper on the *Origin of Starch-grains*, by Schimper, the writer expresses views contrary to those formerly advanced by Naegeli, and he describes bodies to which the name of stärkebildner is given, from which starch may be formed as well as from chlorophyl grains.

The germination of *Welwitschia* has been observed by Bower. Dr. Engelmann, in the Trans. Saint Louis Academy, has some notes on the *Germination of Acorns*, and in the Bot. Gazette, on the *Vitality of the seeds of serotinous cones.* Prof. Sargent also discusses in the Gazette the *Vitality of the Seeds of Pinus contorta.* The Am. Naturalist contains papers by Professor Bessey, on the supposed *Dimorphism of Lithospermum longiflorum*, and by Professor Todd on the *Flowering of Saxifraga tomentosa.* Meehan, in the Proc. Am. Acad. of Philadelphia, calls attention to the *Disarticulacing branches in Ampelopsis.*

Two papers by Gœbel should be mentioned: one on the *Morphology of the Leaf*, and the other on *Dorsiventral Growth*, of which a large number of instances are given. The Arbeiten des Botanischen Instituts, Würzburg, contains a number of important papers on physiology: Sachs on *Material and Form of Plant Organs;* Elfving on *Some Horizontally growing Rhizomata;* Wortmann on the *Relations of the Intramolecular to Normal Respiration in Plants;* and by Francis Darwin on the *Growth of negative heliotropic Roots in Light and in Darkness.* The *Influence of the Direction and Strength of the Illumination on some Forms of Motion in Plants*, is the title of a paper by Stahl, in the Bot. Zeitung. Species of *Mesocarpus* according to Stahl are especially instructive, as in this genus the band of chlorophyl rotates so that by strong illumination it lies in the direction of the light; by weak illumination at right angles to it. Stahl also describes the change of position of chlorophyl grains in cells depending on variations in the illumination. Schwendener has studied the subject of several-celled scheitels, and thinks that although such scheitels exist, they are always composed of fewer cells than has been generally believed, and in the case of *Marratia*, he differs with Russow in only recognizing the existence of four cells.

BACTERIA.

It is only possible to enumerate in this connection comparatively few works having a botanical bearing, the majority of the papers on bacteria being more directly concerned with pathological or chemical questions. The Beiträge zur Biologie contains a paper by Neelsen, called *Studies on Blue Milk*, in which the writer gives the results of careful investigations on the cause of the blue color which is sometimes found in milk. He examined milk which had become blue spontaneously, and was able to produce the color in healthy milk by a process of inoculation, and ascertain by experiment the conditions which favored or retarded the production of the blue color. Of external conditions favoring the production of blue milk the light has no influence, and the temperature within moderate limits has only a slight influence. On the other hand, the presence of free oxygen and atmospheric moisture is essential for its production. The coloring matter of the blue milk is not combined with the bacteria which may be present, but is dissolved in the serum of the milk. A microscopic examination shows the presence of small rod-like bodies, which ultimately form torula-like chains. According to Neelsen, the cells of the chain, which he calls gonidia, remain dormant unless placed in fresh milk, in which case they germinate. Tommasi-Crudelli and Klebs have studied the origin of malarial fever, and conclude that malarial affections which they induced experimentally were produced by organisms which were in the ground in malarial districts before the outbreak of the fever, and whose transmission in the air could be directly observed under definite conditions of dampness and moisture. The organism which greatly resembles *Bacillus subtilis* has been named *B. malariæ*. Hansen claims the priority of having discovered the cause of leprosy to be an organism named *Bacillus lepræ*.

One of the most important papers published during year is that of Dr. Hans Buchner, *On the experimental production of the Contagium of Splenic Fever from Bacillus subtilis*, with observations on the introduction of splenic fever through the organs of respiration. As is well known, *Bacillus subtilis*, a common bacterial form found in decoctions of hay, can scarcely be distinguished morphologically from *Bacillus anthracis*, which is supposed to produce splenic fever in different animals. Buchner undertook to ascertain whether, by varying the conditions of growth, either of these two species might not be transformed into the other; that is, *B. anthracis* might not become harmless when inoculated and *B. subtilis* might not produce splenic fever. He found by cultivation of *B. anthracis* in different solutions, as a solution of Liebig's extract of meat, that it gradually lost its power of producing splenic fever when inoculated, and at the end of what he calls 1,500 generations of the fungus he saw no difference, pathologically speaking, between the two species in question. On the other hand, *Bacillus subtilis*, which had for a certain length of time been cultivated in defibrinated blood, when injected into different animals produced symptoms of splenic fever. The comparative distribution of bacteria in the air has been studied by Miquel, who finds that they are much more numerous in summer than in winter, and he states further that an increase of the amount of bacteria is followed in a few days by an increase in the number of deaths from contagious and epidemic diseases. The communications of Pasteur on the cholera of fowls, and the etiology of splenic fever, and the means of prophylaxis, belong rather to the department of pathology than botany. A paper on the *Cause of Blight in Pear Trees* was read by Prof. T. J. Burrell before the Am. Assoc. Adv. of Science, in which he attributed the disease to the presence of a minute bacterial form. To a similar cause it is also probable that the so-called yellows in peaches is to be attributed. Dr. George Sternberg, U. S. A., has issued a translation of Magnin's *Les Bactéries*, to which he has added original notes and plates.

DISEASES OF PLANTS.

During the year numerous notices have appeared in regard to the spread of the American vine mildew, *Peronospora viticola*, to the vineyards of Europe, where it is said to be causing great harm, especially in Italy. The fungus has been found in several parts of France, Switzerland, Germany as far east as Austria, and in Italy. Rathay has described a deformity of cherry trees produced by *Exoascus Wiesneri.* Hartig has published a number of papers on injurious fungi in a periodical called *Untersuchungen aus dem Forstbotanischen Institut*, the principal of which are *Rosellinia quercina*, which attacks the roots of oaks; *Phytophthora Fagi*, which attacks seedling beeches; *Peziza Willkommii*, which causes a distortion of the larch; and *Nectria Cucurbitula*, which attacks the bark of spruces. The coffee-leaf disease, *Hemileia vastatrix*, has been studied by D. Morris, and a preliminary report on the same subject has been made by H. M. Ward, who was sent by the British Government to Ceylon to investigate the subject. *Die Blasenrost Pilze der Coniferen*, a monograph of the genus *Peridermium*, by Von Thümen, contains an account of the aecidial forms attacking *Coniferæ*, and includes a number of species found in the United States.

THALLOPHYTES.

Algæ.—New American species of algæ have been described in the Bull. Torrey club by Wolle. In the first annual Rep't. Mass. State Board of Health, Charity, and Lunacy is a paper by W. G. Farlow on *Some Impurities of Drinking-Water*, with two plates, illustrating the common species which produce the disagreeable odor sometimes found in the water supplies of Boston.

The most important work on algæ which has appeared during the year is *Florideernes Morphologi* by Agardh. This is a large quarto with 33 colored plates, and was originally presented at the Swedish Royal Academy of Science in 1877, and bears the date of publication 1879, but was not received in this country until 1880. The work is in Swedish, and embodies the author's views with regard to the structure of the frond and fruit of the red-seaweeds. The text has been translated into a Latin form, and under the title of *Morphologia Floridearum* has been issued as an octavo with plates forming part iii of the third volume of the *Species Genera et Ordines Algarum.* Areschoug, in the Bot. Notiser, founds a new genus *Oxyglossum* on *Laminaria japonica*, a species formerly included in *L. saccharina.* Kjellman, in Bot. Tidsk, gives an account of Icelandic algæ, and remarks that the alga flora of Iceland more closely resembles that of Northern Scandinavia than that of Spitzbergen and Greenland. Kuntze, in Engler's Jahrbücher, and also in Nature, gives some observations on the distribution of the gulf-weed, and expresses doubts as to the existence of a genuine sargasso-sea, as described by Humboldt and others. He also gives a revision of the genus *Sargassum*, in which he very much reduces the number of accepted species of that genus. In the Journ. Linn. Soc. Dickie has some *Notes on Algæ from the Amazon and its tributaries.* For Central Europe we have to mention the *Contributions to the Alga-flora of Würtemberg*, by Kirchner. Woronin, in the Botanische Zeitung, describes a new *Vaucheria*, *V. De Baryana*, and a curious algoid parasite, *Chromophyton Rosanoffii*, found in shallow pools in Finland.

In the Mitth. aus der Zoolog. Station of Naples is a paper by Berthold, *Zur Kenntniss der Siphoneen und Bangiaceen*, in which he describes the fertilization in *Bangia*, and the same writer also describes the *Sexual Reproduction in Dasycladus clavæformis.* Schmitz describes the formation of sporangia in the genus *Halimeda.* In Hedwigia P. Richter gives his views on the transformations which the genius *Gloeocystis* undergoes. Borzi has discovered antherozoids in *Hildenbrandtia*, which indicate its affinities with the *Squamarieæ.* Ambronn notices some *Cases of Bilaterality in Florideae* in the Bot. Zeitung. Grevillea contains an account by M. C. Cooke of Desmids found in Great Britain since the publication of Ralfs's *Desmidiaceæ.*

Lichens.—But very little has appeared in this department. Several short articles were published in Flora, among which were *Addenda nova ad lichenographiam europeam; Lichenes nonnulli insulæ St. Thomæ*, by Nylander; the continuation of Arnold's papers on Tyrolese lichens and *Lichenological Contributions* by J. Müller. A monograph of the Scandinavian *Arthoniæ* has been published by Almquist, and descriptions of species from Australia and the Argentine Republic have been published by Krempelhuber. A paper was read by George Murray before the Linnean Society, in which he suggested that in the gonida of lichens we have what might be called a chlorophyl-screen by means of which the hyphae are able to decompose carbonic acid. In Cohn's Beiträge zur Biologie is an interesting paper by Dr. Frank Schwarz, called *Chemisch-botanische Studien über die in den Flechten vorkommenden Flechtensaüren*, in which he not only discusses the different acids, as chrysophanic, lecanoric, erythrinic and evernic acids, in relation to their chemical composition, but also from an histological study of the thalli of different lichens has attempted to ascertain exactly where the acids are found in the thallus.

Fungi.—On fungi relating to the United States several papers have been published. In the Bull. Torrey club is a description of a new fungus, *Simblum rubescens*, by W. R. Gerard, with two plates. This curious fungus belongs to the *Phalloidei*, and at the end of the paper mentioned Gerard gives a list of the species of *Phalloidei* found in the United States. The same writer has also two other papers in the Bulletin on *Additions to the U. S. Phalloidei*, and *Correlation between the Odor of the Phalloids and their Relative Frequency.* In the same journal is a paper by Peck on *Polyporus volvatus* and its varieties, in which he founds a new genus *Cryptoporus* on this species, and an article by J. B. Ellis on a *New Sphae-*

ria on Grapes, *Sphaeria Bidwellii*, which he regards as the ascigerous condition of *Phoma uvicola* B. and C. In the Bot. Gazette are *Notes on Fungi*, by M. E. Banning, and *North American Species of Septoria*, by Von Thuemen; a *Catalogue of the Pacific Coast Fungi*, by H. W. Harkness and J. P. Moore, including a large number of species, was read before the California Academy of Sciences and afterwards issued in an octavo form. Grevillea contains papers on California fungi, by Cooke and Harkness, and on New York fungi, by Cooke.

The fungi of the herbarium of the late M'lle Libert have been the subject of papers in Grevillea by Cooke, *Reliquae Libertianæ*, and by Roumeguère and Spegazzini in the Revue Mycologique, *Revisio Reliquiæ Libertianæ*, and specimens have been distributed also by Von Thüemen in Mycotheca Universalis. Cooke has a number of papers in Grevillea; *Observations on Peziza;* on *Hymenochaete and its allies;* descriptions of British and Indian fungi; and South African and Australian fungi by Kalchbrenner and Cooke. Hedwigia has a number of notices of Swiss fungi, especially *Uredineæ*, by Winter, and new fungi from the Jura and the Vosges are described in Grevillea by Quelet. Additions to the mycological flora of Finland have been made by Karsten, and to the Italian flora by Saccardo, Spegazzini, and Passerini in Michelia, and the Atti Soc. Critt. Ital. The Revue Mycologique contains descriptions of new fungi by Roumeguère, Von Thümen, Passerini, Spegazzini, and others.

Developmental works on fungi have not been numerous. Hartig has connected *Calyptospora Goeppertiana* Kühn with *Æcidium columnare* A. and S. by means of experimental cultures. Rathay experimented on the connection between different species of *Gymnosporangium* and *Roestelia*, and differs from Oersted in believing that *R. penicillata* is the aecidial form of *G. Juniperinum*, and not of *G. clavariæforme.* The development of the spores in *Urocystis colchici* has been observed by Prilleux, who has a paper on the subject in the Annales des Sciences. In the Beiträge Zur Biologie is a paper by Eidam, *Beitrag Zur Kenntniss der Gymnoasceen*, in which he gives the development of *Ctenomyces serratus* and *Gymnoascus uncinatus.* Fischer, in the Botanische Zeitung, has shown that the enigmatical round and spiny bodies found in *Saprolegnia* species are not organs of the *Saprolegnia*, but parasites, apparently related to *Chytridium.* Reinke has studied the chemical composition of the plasmodium of *Aethalium septicum*, the principal constituent of which he finds to be plastin, which he has studied in detail.

ARCHEGONIATA.

In the United States, the principal publication has been the *Ferns of North America*, by Professor Eaton, which reached completion this year, including in all 181 plates and accompanying descriptions. Besides this principal work there is a paper in the Bull. Torrey Club, on *New or* *little known Ferns* of the United States, by the same writer; who has also issued a *Systematic Fern-List* of the species of this country. In the Bull. Torr. Club are two papers by G. E. Davenport, on a new species, *Notholæna Grayi*, from Arizona, and on *Vernation in Botrychium boreale*, and a paper on *Ferns of the Cumberland*, by John Williamson. The occurrence of the rare *Schizæa pusilla* in Nova Scotia is recorded by Professor Gray in the Bot. Gazette. In the same journal are notes by Professor Gray and E. J. Loomis on an automatic movement of the frond of *Asplenium Trichomanes*.

Baker describes some new ferns, collected by Beccari in Sumatra, and a collection from Madagascar by Langley Kitching in the Journal of Botany, where the same writer has also published a *Synopsis of the Species of Isoetes*. In the Trans. Linn. Soc. is a *Review of the Ferns of Northern India*, by C. B. Clarke.

In the department of mosses and hepatics there has appeared in the United States a *Catalogue of North American Mosses*, by E. A. Rau and A. B. Hervey, and *Bryological Notes and Criticisms*, by C. F. Austin, in the Bull. Torrey Club. An important work is *Sphagnaceæ of Europe and North America*, by R. Braithwaite, and the *British Moss-Flora*, part 2, including the *Buxbaumiaceæ* and *Georgiaceæ*, by the same author. The Annales des Sciences contain a paper by Bescherelle, entitled *Florule Bryologique de la Réunion*, which also includes mosses from other neighboring islands. Lindberg has published notes on Scandinavian mosses and C. Müller a *Prodromus Bryologiæ Argentinæ*, the last named paper being a continuation in the Revue Bryologique. In Grevillea and in the Trans. of Bot. Soc. of Edinburgh are notes on *British Hepaticæ* by Carrington. The *Jungermanniaceæ* have been studied by Gottsche who has published new observations on the *Geocalyceæ* and Stephani has published a paper on the *Jungermanniaceæ* of Germany with illustrations.

Treating of *Characeæ* we have to notice the appearance of two numbers of the *Characeæ of America*, by Dr. T. F. Allen, in which three species of *Nitella* and three of *Chara* are described and figured. Dr. Allen has also an article in the Bull. Torr. Club on the *Similarity between the Characeæ of America and Asia* in which he calls special attention to *Nitella polyglochin* A. Br. and *Chara Hydropitys* Reichenb. A *Review* of the *British Characeæ*, by Henry and James Groves, is given in the Journal of Botany.

On the general development of the higher cryptogams is to be mentioned *Die Gefässkryptogamen* by Sadebeck, in the Encyklopaedie der Naturwissenschaften and Goebel's *Embryologie der Archegoniaten* in Arbeiten Bot. Instituts in Wurzburg. Leitgeb has published several important papers on *Marchantiaceæ*, especially with reference to their inflorescence and stomata in the proceedings of the Vienna Academy. Cramer has an illustrated paper on the *Non-sexual increase of the Fern-*

prothallus, in which he figures some curious forms of buds and what he calls conidia, and in Kosmos is an article by Dodel-Port on the peculiar forms which fern-prothalli assume when grown under water.

PHÆNOGAMS.

The most important work published during the year in the United States is the second and final volume of the *Flora of California*, by Sereno Watson. The work was published under the auspices of the Geological Survey of California, aided by private subscriptions. In the work Mr. Watson was aided by Dr. Engelmann, who elaborated the oaks, pines, and *Loranthaceæ;* by M. S. Bebb on the willows; William Boot on *Carices;* Dr. George Thurber on the grasses; and Professor Eaton on the higher cryptogams. The work ends with the mosses, the lower cryptogams being entirely omitted. The appendix contains a glossary and a *List of Persons who have made botanical collections in California*, by Prof. W. H. Brewer. The botanical contributions of Professor Gray in the Proc. Am. Acad. Arts and Sciences comprise *Notes on some Compositæ*, which form a sort of prodromus of that order in the Synoptical Flora; *Some Species of Asclepias; A New Genus of Gentianaceæ, Geniostemon* including two Mexican species; and *Miscellaneæ of the North American Flora*, including the new genus *Reverchonia. The Vegetation of the Rocky Mountain Region*, by Professor Gray and Sir J. D. Hooker, published in the Bull. U. S. Geol. and Geog. Survey, although bearing the date 1880, was not in reality made generally public until 1881. The Trans. St. Louis Academy contain a *Revision of the genus Pinus and Description of Pinus Elliottii*, by Dr. Engelmann, with three folio plates by Roetter. In the Botanical Gazette are several notices by Professor Gray, of which may be mentioned an account of the genus *Leavenworthia*, of which four species are described. In the same journal Engelmann describes a new species of *Catalpa, C. speciosa;* Mr. T. Morong describes some new species of *Potamogeton*, and Professor Porter a new species, *Habenaria Garberi.* Bailey gives an account of *Michigan Lake Shore Plants;* I. C. Martindale, under the title of *Germination and Growth of Parasitic Plants*, relates his experience with *Orobanche minor.* The same botanist gives an account of the so-called *Bartram Oak*, in which he concludes that *Quercus heterophylla* Mchx. is a distinct species. J. Donnell Smith has in Bull. Torr. Club a note on *Wolffia gladiata* var. *Floridana*, in which he includes some remarks by Hegelmaier on that species. Prof. C. S. Sargent has issued a *Catalogue of the Forest Trees of North America* in connection with the work of the Census Bureau.

Of foreign works may be mentioned Elmes's *Monograph of the genus Lilium*, a folio with 78 colored plates, and J. G. Baker's *Synopsis of Aloineæ and Yuccoideæ* in the Journ. Linn. Soc. Several additions have been made during the year to works on local floras which had appeared in part in previous years. The *Flora of British India*, by Hooker, has been continued in part seven to the *Rubiaceæ;* the *Biologia centrali-americana*, the botanical part of which is by Hemsley, contains the orders from *Rosaceæ* to *Loasaceæ;* the *Flora Brasiliensis*, fasc. 76, containing *Lemnaceæ* by Hegelmaier, and *Araceæ* by Engler, was published this year, although the last-named order had been in press for some time. Fournier's *Mexicanarum plantarum enumeratio* is devoted to the grasses, and the same writer has a paper on the geographical distribution of Mexican grasses in the Ann. Sci. Nat., in which he remarks that of the 643 species in Mexico 371 are peculiar to that country. *Adansonia* contains a number of papers by Baillon on the development of the flowers in *Berberidaceæ*, *Selaginaceæ*, and *Stylidiaceæ*. Concerning oriental plants, we have to mention Regel's *Description of Plants from Central Asia*, cultivated in the Botanic Garden at St. Petersburg; *Diagnoses plantarum novarum asiaticarum*, by Maximowicx, in the Bull. Acad. Imp. of St. Petersburg; *Spicilegia Floræ Sinensis*, by Hance, in Journ. Linn. Soc. A succinct account of the Japanese flora is to be found in Rein's work entitled Japan, and a short notice of Madagascar plants is given by Baker in Nature. The grasses of New Zealand are described by Buchanan in a *Manual of indigenous grasses of New Zealand.* The *Fragmenta Phytographiæ Australiæ* of Baron F. von Mueller has been continued in two parts, and the same writer has issued a fifth decade of *Eucalyptographia*, a descriptive atlas of the species of *Eucalyptus* of Australia and the adjacent islands. In the Gardener's Chronicle is a paper on *Cinchonas*, and a controversy on the subject of species of *Cinchona* has been carried on in the Bot. Zeitung by Kuntze and Karsten.

There appeared in 1880 the first volume of *Botanische Jahrbücher für Systematik, Pflanzengeschichte, und Pflanzengeographie*, edited by Engler and issued by Englemann, of Leipzig. The first volume contains a large number of interesting papers relating to phænogams, amongst which may be enumerated: Beccari's *Pflanzengeographie des Malayischen Archipels*; Focke's *Natürliche Gliederung und die geographische Verbreitung der Gattung Rubus*; Buchenau's *Verbreitung der Juncaceen über die Erde;* Engler's *Beiträge zür Kenntniss der Araceæ* and *Verbreitung der Gattung Rhus*; and Lange's *Studien über Grönlands Flora.* In connection with the distribution of species should be noticed *Quelques observations sur la Flore Alpine d'Europe*, by Bonnier, in which he compares the notes made by him on plants collected in the Carpathian Mountains, the Austrian Alps, and the Tyrolese Alps, and concludes that the constitution of the soil has little to do with the distribution of species, which depends, as De Candolle maintained, on the sums of the temperatures.

ZOOLOGY.

By Theodore Gill.

GENERAL ZOOLOGY.

FEATURES OF PROGRESS.

The progress of Zoology in the biennial period just past has shown the usual features exhibited during the present decade. The doctrine of evolution is now not only recognized by all scientific workers in biology, but it is postulated as the starting-point for investigations into the affinities of various types, and the efforts of biologists are in a great measure directed to the ascertainment of the philogeny and derivation of the various types. This has been exemplified during the past two years in attempts at tracing the genealogy of the mammals, the cephalopods, and the acalephs, as well as various groups of the branches and classes of the animal kingdom; as, for example, the carnivorous mammals, the ungulates, various worms, &c.

Perhaps the most prominent feature of the period surveyed has been the discovery of numerous deep-sea types, mostly resulting from the voyage of the English ship Challenger, but in part also the fruits of dredging of minor expeditions and surveys; for example, the survey of the Caribbean Sea and Gulf of Mexico, under the auspices of the United States Coast Survey; the explorations of the United States Commission of Fish and Fisheries, and the Norwegian expedition to the Arctic Seas in 1876 to 1878. These several expeditions and surveys have been fruitful in the finding and revelation of many remarkable forms. So rich have been the results that, as we shall hereafter see, about 2,000 species of a peculiar group—the Phæodaria—have been made known by a single naturalist, mostly from the collections of the Challenger expedition. Our knowledge of the fishes of the deep sea has also been greatly increased.

An especially noteworthy feature in the taxonomy of 1879 and 1880 has been the establishment of a number of "orders" in various groups of the animal kingdom. In view of the disparity in value of these groups, in the several departments of zoology, it seems fitting to utter a few words of caution and explanation in this place. What is an order? and what shall be the limits to the range of variation of the forms included under such designation? are questions that must naturally suggest themselves and be answered. In the first place, of course, orders, like every aggregation of animals and plants, must to a large extent be arbitrary, and their relations have to be determined by a certain standard, from which greater or less deviation must be made in individual cases, according to circumstances. The standard, however, as will be admitted by probably every rational zoologist, should be a type that from its nature and relations may be readily comprehensible and appreciated by the greatest number, and in regard to which there is general concurrence. Undoubtedly it is in the class of mammals that we find such requisites present in the greatest degree. Accepting Linnæus as the originator, *pro tanto*, of the *idea* connected with the name order, we naturally look to his exposition of the mammal groups. We find that though there have been great deviations from his applications since his day, the fundamental idea of the group, as it exists in nature, has been accepted, and the efforts of subsequent zoologists have been chiefly in the direction of refinement and definition. There is now a general concurrence as to the orders recognizable in the class of mammals, although some little difference as to details still prevails. Taking the most comprehensive ones, we have the Primates, Carnivores, Ungulates, Cetaceans, Sirenians, Chiropters, Insectivores, Rodents, and Marsupials. Now, inasmuch as several of these have been subdivided, let it be assumed that no groups between which exist greater morphological differences than those which differentiate the orders, with their maximum limits, from those nearest of kin, shall be regarded as less than orders; and, on the other hand, that we shall not distinguish as orders such groups as have at least less differences than those separating, for example, the Anthropoid and Lemuroid Primates, the Fissiped and Pinniped Carnivores, and the Perissodactyle and Artiodactyle Ungulates. From this starting-point it will be in place to examine a couple of systematic attempts published during the past year. One has been a new revision of the class of Birds; another, a reiterated classification of the Fishes.

In all nature, among the major aggregates of species, there is not a more natural and homogeneous group than that which naturalists unanimously have agreed to consider as a class under the name of Birds. So like are all the living representatives of this group in all essential details of their morphology, that between the extremes there certainly exist less differences than those which separate the cetaceous from any other order, and perhaps less even than those which separate the Anthropoid and Lemuroid Primates, or the Fissiped and Pinniped Carnivores. Nevertheless, the last reviser of the class has admitted no less than 26 orders. If the proposition that the order of Mammals is a proper standard be accepted, there can be no question but that differentiation in the class of Birds has been carried to a most unscientific extreme.

The opposite extreme has been displayed in the treatment of the classification of Fishes, in part at least, but at the same time a like extreme in excessive differentiation. Dr. Günther has published an "Introduction to the Study of Fishes," in which he recognizes as orders certain artificial groups of Teleosts current for a long time; that is, the Acanthopterygii, Acanthopterygii Pharyngognathi, Anacanthini, Physostomi, &c.

The characters used to differentiate these "orders" fail in certain representatives referred to each group, and are of really little more systematic importance in several cases than those used to distinguish the "orders" of Birds. Nevertheless, to each of the "orders" in question are assigned forms which do really differ in important anatomical details, and which have far less relation to the types with which they are confounded than do the *types* of the so-called orders exhibit *among themselves.* We have, consequently, evils here, not only of undue valuation, but also radical defects in appreciation of relationships. But the same author applies a standard as different as possible to the classification of the generalized types of Fishes; committing, at the same time, the great mistake of calling those generalized types the highest. All the typical Ganoids, as well as the Polypteroids, and Dipnoans are confused together in one heterogeneous order; all the Chimæroids, and all the Sharks and Rays, are thrown together in a second. There can be no question but that representatives of each of these last two so-called "orders" exhibit far greater diversities in their structure, *inter se*, than do any of the orders of existing mammals. It is difficult to believe that any consideration could have been given to the principles of taxonomy, or that thought could have been actively involved in such schemes as the last one noticed.

As to the new orders recently proposed, and to be noticed hereafter, it is probable that the value of the several groups endowed with such rank will be questioned by the majority of naturalists, and that the types so distinguished will ultimately be degraded in rank.

The language of the original from which the abstract is compiled is followed as closely as the case will permit, as the advantages of such a course must be obvious to all on a little reflection. It has however been generally found to be necessary to limit the abstract to the illustration of the prominent idea underlying the original memoir, and pass by the proofs and collateral arguments. At the same time it has been often attempted to bring the new discovery into relation with the previous status of information respecting the group under consideration. As to the special discoveries recorded, they have been generally selected (1) on account of the modifications the forms considered force on the system; or (2) for the reason that they are or have been deemed to be of high taxonomic importance; or (3) because the animals *per se* are of general interest; or, finally (4), because they are of special interest to the American naturalist. Of course, zoologists cultivating limited fields of research will find in omissions cause for censure, and may urge that discoveries of inferior importance have been noticed to the exclusion of those better entitled to it. It is freely admitted that this charge may even be justly made; but the limits assigned to the record have been exceeded, and the recorder has studied the needs of the many rather than of the few. The summary is intended, not for the advanced scientific student, but for those who entertain a general interest in zoology or some of the better-known classes.

The compilation of this record has been greatly facilitated by the "Zoologischer Anzeiger" of Professor Carus and the very useful synopses published in the Journal of the Royal Microscopical Society of London. The value of both of the records thus referred to is, however, very greatly reduced by the absence of an index to names of authors cited in the first, and to the neglect to give a reference to the exact title and place of publication of the original paper in connection with the abstract in the latter case. The consequence is that very much valuable time must be lost to confirm and find references.

ANAL RESPIRATION IN ANIMALS.

Mr. M. M. Hartog, in connection with observations on the anal respiration of *Cyclops*, as well as *Canthocamptus* of the Harpacticidæ and *Diaptomus* of the Calanidæ, has enumerated the forms of Invertebrates in which anal respiration is manifested.[*] These belong to the following classes and major groups:

VERMES:
  Rotifera.
  Gephyrea.
  Oligochæta-Limicola.
ECHINODERMATA:
  Holothuroidea.
ARTHROPODA:
  Crustacea (generally).
  Insecta (aquatic larvæ generally).
MOLLUSCA:
  Dentalium.

PHOSPHORESCENCE IN ANIMALS.

Mons. Jousset de Bellesme has continued his researches upon the phosphorescence of animals by a special investigation of that of the glow-worm.[†] He concludes that the phosphorescent substance is probably a gaseous product, for the structure of the gland does not give us the idea of an organ with a liquid secretion. The chemical products which are phosphorescent at ordinary temperatures are not numerous, and the one which chiefly occurs is phosphureted hydrogen. This, M. Jousset de Bellesme is led to believe, is the case in the glowworm, and he is influenced in his opinion by the extreme resemblance observable between the phosphorescence of substances in decomposition which is due to the evolution of phosphureted hydrogen and that of luminous animals. They present, he thinks, the same physical characteristics, the same affinity for oxygen, the only difference being that the cadaveric phosphorescence is continuous, while the phosphorescence of animals is intermittent. But the latter is due to the fact that the cellular decomposition which sets free the luminous product takes place in animals of high organization only under excitation of the nervous system, and in the lower animals (*e. g.*—*Noctilucæ*) only by means of external excitants.

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[*] Hartog (M. M.). On the Anal Respiration of the Copepoda. *Quart. Jour. Micr. Science,* vol. xx, pp. 244, 245.

[†] Jousset de Bellesme. Experimental Researches in the Phosphoresence of the Glow-worm. *Ann. Mag. Nat. Hist.* (5,) vol. v, pp. 345–347. (Translated from the *Comptes Rendus,* vol. xc.) Printed in full in the *Journ. Anat. et Phys.*, vol. xvi, pp. 121–169.

The author has been led by his investigations to regard phosphorescence as a general property of protoplasm consisting in the evolution of phosphureted hydrogen.

This view readily explains why many of the lower animals, although destitute of a nervous system, are phosphorescent, and has the additional advantage of connecting the phenomena of phosphorescence observable in living animals with those exhibited in organic matters in course of decomposition. It is, he concludes, another example of a biological phenomenon very closely related to an exclusively chemical cause.

LIGHT AND ITS EFFECTS ON ANIMALS.

It may be recalled that some years ago General Pleasonton recorded some startling ideas with respect to the influence of blue light. As the observations were evidently made in a very crude fashion, little attention was paid to them. The subject of the influence of different colored rays has been made the subject during the past year of special investigation by Moleschott and Fubini.* The eggs of a frog and toad were placed in vessels and covered with glasses or fluids of different colors. "At first the developmental processes did not differ among the different ova, or from those which were exposed to ordinary daylight." When rotation commenced, however, it was found that the eggs exposed to red light rotated most rapidly, while great torpor was exhibited by those under the blue glass; the rest, exposed to yellow or green light, did not differ at all from those developed under uncolored glass. "The most greedy were those under the blue glass. When brought from their artificial influence, its effects gradually passed off. When changed from one color to another, the activity displayed became gradually more or less." In investigating the action of different kinds of colored light on the excretion of carbonic acid, the following results were obtained:

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* Moleschott and Fubini. *Jour. Roy. Micr. Soc.*, vol. ii, pp. 138, 273, and vol. iii, p. 409. Also, E. Yung, on the influence of colored light on the development of animals. *Comptes Rendus* Acad. Sci. Paris, vol. xci, pp. 440, 441.

	Darkness.	Red.	Blue-violet.	White.
Uninjured frog	100	100.5	115	112
Uninjured bird	100	128	139	142
Uninjured rat	100	111	140	137
Blind mammal	100	109	114	113

It is concluded that light has "a considerable influence on metabolic activity. It increases the excretion of carbonic acid and the ingestion of oxygen, but this influence is not only mediate through the eyes, it obtains through the skin, for it is seen in eyeless animals. When the eyes only or the skin only are affected, the result is less than when the whole animal is brought under its influence. The tissues are no less affected than the whole body. The chemical rays have greater effect than the heating ones, and the result that light has a chemical influence on metabolism cannot be evaded." (Abstract from *J. R. M. S.*)

EFFECTS OF STARVATION.

Surg. D. D. Cunningham, of the Indian medical service, has investigated the physiology of starvation in certain fungous plants, and Amphibans (of the tadpoles of a toad—*Bufo melanostictus* and a frog—*Rana tigrina*).* The result of his investigation was to demonstrate that a fatty degeneration and disintegration of the protoplasm ensued, and in the animals an atrophy of the intestinal canal. The fatty degeneration effects in the greatest degree the lining cells of the digestive canal, and this in time is completely left destitute of epithelium, and therefore no longer capable of fulfilling the functions of secretion and absorption. When this climax is reached death must ensue, but as long as any of the epithelium is left (even though it be much degenerated) recovery is possible. In connection with these experiments Surgeon Cunningham has studied the phenomena exhibited by starvation in the case of the inhabitants of India who suffered and died from the famine lately prevalent in that country. Although patients that had been for some time deprived of food showed no symptoms of actual disease, they were attacked by diarrhœa and dysentery with almost certainly fatal results, and thus was indicated inability for assimilation. A post-mortem examination proved that there was, as in the case of the plants and animals experimented upon, a fatty degeneration of the tissues, especially the alimentary canal. So long, however, as the sufferers had a small amount of nutriment no active symptoms were manifested, and it was only when they were afforded a generous supply, that famine diarrhœa and dysentery commenced. The most rigorous attention and regimen were found to be ineffectual in advanced cases; but if only slight degeneration of the tissues had taken place, food judiciously supplied counteracted the effects of previous privation. As soon, however, as extensive degeneration had taken place no care was sufficient to recuperate the patient.

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* Cunningham (D. D.). Certain effects of starvation on vegetable and animal tissues. *Quart. Jour. Micr. Science*, January, 1880.

RHIZOPODS.

A NEW "CLASS" OF RHIZOPODS.*

As long ago as 1859, Professor Haeckel had known several peculiar forms of Rhizopods, which he subsequently described in a monograph of the Radiolaria as representatives of three distinct families. In 1879 Hertwig differentiated these forms, with others subsequently made known, as an order of Radiolaria, under the name "Tripyleæ." A large number of forms belonging to the group were obtained by the Challenger expedition, and have been subjected to a critical study by Haeckel, and, as Murray first showed, "a striking character of all these Rhizopods is the constant presence of large dark-brown pigmented granules, scattered irregularly round the central-capsule, and covering the greater part of its outer surface." This extra capsular mass is called by Haeckel the "phæodium" (dark brown or dusky). "The phæodella, large brown granules of the 'phæodium,' are not, as Murray supposed, true pigment cells, as a true cell nucleus can not be observed in them; and the nature of the peculiar pigment of these pseudo-cells is not precisely known; but the quantity and constancy with which the 'phæodium' appears in all 'Phæodaria,' while it is wanting in all the typical Radiolaria, gives the Phæodaria a high degree of systematic importance." On account of this "constant presence of the phæodium, and the peculiarly constructed membrane of the central-capsule," the type thereby differentiated is isolated and a distinct "class" constituted for it. The species generally attain considerable size, in comparison with other Radiolaria, and are even visible to the naked eye. Many are a half millimeter or more in diameter. "The conspicuous central capsule is usually round or spheroidal: it is, however, often egg-shaped or somewhat oval. In many cases it is monaxial; in others dipleuric. Its membrane is very firm and always double, the outer layer very thick, the inner thin. The opening through which the pseudopodia appear has the very peculiar structure accurately described by R. Hertwig. Many Phæodaria have only one such opening (*Monopyleæ*), others have two at the opposite poles of the central-capsule (*Amphipyleæ*)," and still others more. The siliceous skeleton is extra capsular. Although the principal forms of this group have analogues among the typical Radiolara, they are usually readily distinguished from them. Haeckel has proposed ten "families," and these have been segregated by him under four "orders," distinguished severally by characteristics of the skeleton, or the absence of a skeleton. He has found among the forms examined by him what he calls more than 2,000 new species!

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*A new class of Rhizopoda. *Nature*, vol. xxi, pp. 449–451, March 11, 1880

HYDROZOA OR ACALEPHS.

WATER IN MEDUSÆ.

Some time ago it was stated by Professor Mobius that in a specimen of *Aurelia aurita*, from the Bay of Kiel, it had been ascertained that there was 99.82 per cent. of water, and consequently the solid matter could only have formed a small fraction of 1 per cent. This statement was so remarkable that, before acceptance, it required verification, and Dr. Krukenberg has recently examined specimens of the class, with the object of verifying or disproving the allegation.*

Specimens of *Aurelia* found at Triest were examined, and it was found that the water formed only from 95.84 to 95.79 per cent. of the total, the solid existing in the ratio of from 4.21 to 4.66 per cent. *Chrysaora hyoscella* afforded 95.75 per cent. to 96.3 per cent. of water, and there was from 3.7 to 4.25 of solid substances. A large specimen of *Rhizostoma Cuvieri* was found to contain 95.392 per cent. of water, and consequently nearly 5 of solid matter, of which there were 1.608 per cent. of organic and 3 per cent. of inorganic substances. It was concluded that probably the Medusæ generally exhibit a close approximation to these results, and that in none is there so small a percentage of solid matter to be found as in the case instanced by Mobius.

EXTRA-MARINE MEDUSÆ.

There is, perhaps, no type of animals that has been generally regarded as being so eminently characteristic of the open sea as the Medusæ. While representatives of the class exhibiting the hydriform condition have of course been long well known as inhabitants of fresh waters, until recently none of the medusiform groups have been specially noticed as having been found elsewhere than in the sea. It has been said of them that they dread nothing more than fresh water, and that such water is really poison to them; that even brackish water kills them immediately; and, further, that they need a water rich in oxygen and constantly renewed by movements of the waves and currents. "The *Medusæ*, in fact, have almost an equal dread of fresh water, of stagnant sea-water, and of a slightly too high temperature." Several cases, however, have been recorded within the last two years which must materially modify the accepted beliefs with regard to their habitat.

FRESH-WATER MEDUSÆ.

Mr. Agassiz has shown† that the idea respecting the exclusive confinement of Medusæ to perfectly salt and clean sea water is exaggerated. He records that in an estuary back of Boston harbor, at West Boston bridge (about one mile from the head of the harbor), and where the water, at the last part of the tide, is almost fresh and has a very slight salt taste, there is an abundance of Hydroids, which "thrive remarkably well on the drainage of the district, and grow to an unusually large size." The species which have free medusæ are *Eucope diaphana*, *E. pyriformis*, and *Obelia commissuralis*, and these are twice during 24 hours of the day exposed alternately to salt and nearly fresh water, and thrive under the change, both in their hydriform and medusiform conditions. Other medusæ found near the same place, and which, at low tide, were in fresh water, were species of *Sarsiæ*, *Piaropsis*, and *Aurelia*, and these seemed unaffected by the large quantity of fresh water in which they were found.

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* C. F. W. Krukenberg. On the distribution of the water of the organic and inorganic compounds in the body of Invertebrates. *Vergl.-Physiol. Stud. Küst. Adria.* I, part ii, pp. 78–106. (*J. R. M. S.*)

† Agassiz (Alexander). As quoted in *Journ. R. Micr. Soc.*, vol. iii, p. 968.

NEW PALUDICOLOUS MEDUSA.*

In 1876, Dr. Du Plessis discovered "in the middle of the discharging canal of the salt-works of Villeroy, near Cette," a Medusa which inhabits in the summer the stream thereof and the near-lying waters. The canal is about two or three yards broad and one deep. "The soil is a black putrid mud, stinking of sulphureted hydrogen," and the water is perfectly stagnant, very brackish, and exposed all day long to the full rays of the sun. "The Medusa always inhabits the lower surface of islets of floating algæ. On removing these it is seen clinging like a flake of jelly, shining like crystal." They only occur in June and July, and were looked for in vain in spring as well as in September and October. The Medusa in question was ascertained to belong to the genus *Cosmetira*, a representative of the family of Oceanidæ, and is very closely related to, though much smaller than, the *Cosmetira punctata*, which is abundant in the contiguous sea. Dr. Du Plessis, who described the species in 1879, considers that it furnishes an example of the influence of the surrounding medium in the gradual modification and transformation of one species into another, for he doubts not that the diminutive *Cosmetira* is a decendant of the *Cosmetira punctata*, from which it has become modified and reduced greatly in size, while the canals and stomach have assumed a green color, and the general rose-color of the oceanic form has been changed into violet, while the tentacles become black.

A FRESH-WATER JELLY-FISH.†

In the summer of 1880 Mr. Sowerby, the secretary of the Royal Botanical Society of London, noticed quite a number of small animals, which were soon ascertained to be medusæ, in a warm-water tank in which plants of the *Victoria regia* were growing in the garden of that society. The water in the tank had a temperature of about 90° F., and was literally swarming with the little medusæ, the larger of which measured nearly half an inch in transverse diameter. They were very energetic in their swimming, and displayed the characteristic systole and diastole of the umbrella, and were flourishing apparently in the very conditions which contribute most completely to their well being. Specimens of this form were obtained by Profs. E. Ray Lankester and Geo. G. Allmann, and described by the former June 17, and by the latter June 24, in "Nature"; by the former, under the name *Craspedacusta Sowerbii*, and by the latter as *Limnocodium Victoria.* Subsequently an attempt to compromise on the name was made, and Professor Lankester desired to perpetuate the designation of *Limnocodium Sowerbii.* Inasmuch, however, as *Craspedacusta* was first used and accompanied by a satisfactory diagnosis, there can be no question but that conformity with the laws of nomenclature compels its retention. The most characteristic feature of the new form is the development of otoliths and velar canals. The otoliths are "placed along the line of insertion of the velum—about 80 in number (fewer in small specimens). From 16 to 20 are placed between successive perradial tentacles arranged in groups of two or three between the successive secondary tentacles." The velar centrifugal canals "(which are really the elongated otocysts) are peculiar to this genus; passing from the otoliths (one inclosing each otolith) into the velum, and then ending blindly. They appear to correspond to the *centripetal* canals found in other Trachomedusæ, in the disk." By Professor Lankester it is claimed that *Craspedacusta* belongs to the family Petasidæ among the Trachomedusæ, which are distinguished by the development of "*four* radial canals, in the course of which four gonads lie, with a long tubular stomach, and no stomach-stalk." According to Professor Allmann, however, while some of the characters "point to an affinity with both Trachomedusæ and Narcomedusæ, this affinity ceases to show itself in the very important morphological element afforded by the marginal bodies. In both Trachomedusæ and Narcomedusæ the marginal bodies belong to the tentacular system; they are metamorphosed tentacles, and their otolite cells are endodermal, while in the Leptomedusæ, the only other order of craspedototal Medusæ in which marginal vesicles occur, these bodies are genetically derived from the velum. Now, in *Limnocodium* the marginal vesicles seem to be as truly velar as in the Leptomedusæ. They occur on the lower or abumbral side of the velum, close to its insertion into the umbrella, and the tubular extension of their capsule runs along this side to the free margin of the velum, while the delicate epithelium of the abumbral side passes over them, as in the Leptomedusæ. It is true that this point cannot be regarded as settled until an opportunity of tracing the development is afforded; but in very young specimens which I examined I found nothing opposed to the view that the marginal vesicles were derived, like those of the

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* Du Plessis, G. Etude sur la Cosmetira salinarum, sp. n., nouvelle Méduse paludicole des environs de Cette. *Bull. Soc. Vaud.* (2,) vol. xvi, pp. 39–45, pl. Also, *An. Mag. Nat. Hist.* (5), vol. iii, pp 385–389.

† Lankester (E. Ray). On a new Jelly-fish, of the order *Trachomedusæ*, living in fresh water. *Nature*, vol. xxii, pp. 147–148, June 17, 1880. See also vol. xxii, pp. 177–181, (Lankester, Allmann, Romanes); 218 (Allmann); 241 (Lankester); 290 (Allmann); 316 (Lankester).

Leptomedusæ, from the velum." It is concluded that *Limnocodium* "will hold a position intermediate between the Leptomedusæ and the Trachomedusæ; but as the greatest systematic importance must be attached to the structure and origin of the marginal vesicles, its affinity with the Leptomedusæ must be regarded as the closer of the two."

ECHINODERMS.

A NEW ORDER OF HOLOTHURIOID ECHINODERMS.*

Quite a number of remarkable forms have been procured within the last five years at great depths of the ocean in various parts of the world, and these have been recently brought together by Hjalmar Théel in one group, differentiated as an "order" closely related to the Holothurioidea. These newly discovered forms essentially resemble the Holothurioids in general structure. It is noted, however, that the Holothurioids are mostly fusiform or cylindrical in shape, although some (*e. g.*, *Psolus* and *Cuvieria*) are most decidedly bilateral; the radiate symmetry prevails so far externally that the five radial ambulacral vessels and their appendages are generally similar, or nearly so, and run symmetrically at equal distances from one another from the anal to the apical pole, and they may be even used indifferently for the purpose of progression; but, nevertheless, of these five ambulacra, three—constituting the trivium—are ventral, and the other two—the bivium—are dorsal. While such is the rule however the exceptions are such as to compel us to be cautious, lest we place an undue value on deviations even much less than those recognized as occurring in forms universally conceded to be true representatives of the order.

In the newly discovered forms the body is always "distinctly bilateral," (1) "the lateral ambulacra of the trivium bearing large, slightly retractile pedicels, disposed either in a single row, or sometimes in two rows, along each side of the ventral surface, and sometimes with another series of larger highly elongated not retractile processes placed externally and above the pedicels; pedicels of the two lateral ambulacra symmetrically arranged, being more or less distinctly opposed across the ventral surface"; (2) "the odd ambulacrum naked, or very seldom with a few rudimentary pedicels"; (3) "bivium provided with very long, not retractile processes, often disposed in one or more rows along each of its ambulacra, and more or less distinctly opposed across the dorsal surface, or with only a few rudimentary ones in its anterior part, or with a single very large one resembling a broad, branched or unbranched lobe, and near to it some small papillæ;" (4) there are "no respiratory trees;" and (5) the integument is "naked, spiculous, or plated." Such are the characteristics common to the forms. While the ordinal value of this type may perhaps be generally disputed, the forms are of no little interest. Ten distinct genera have been differentiated and are represented by seventeen known species. These have all been obtained in the deep sea, at great depths. They exhibit extraordinary proportions and development of the ambulacral appendages, and their singularities have given rise to some remarkable generic names, as *Deima* (a fright), *Oneirophanta* (a vision), *Ilyodemon* (ooze spirit), and *Irpa* and *Kolga* (both names derived from the Norse mythology). "One group is very gelatinous, and of a rich purple color; others are gelatinous, gray, and semitransparent; while another series, and among these the most fantastic of the whole, are yellowish, and have a crustaceous test, with a thick layer of calcareous plates, often running out into strangely shaped processes. A peculiar little group from the Antarctic Sea are little more than a gelatinous membrane, covering an enormously distended intestine, filled with diatom ooze." It is evident that the type is quite characteristic of the abyssal fauna, for in most hauls of the dredge made in very great depths forms are brought up in considerable number.

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* Hjalmar Théel. The Elasmopoda, a new order of Holothurideæ. *Nature*, vol. xxi, pp. 470–473, March 18, 1880.

SYSTEM OF STAR-FISHES.

Mr. C. Viguier has investigated the comparative anatomy of the skeleton of star-fishes, and in connection therewith has applied the data gained to the revision of the system.* He first recognizes two primary groups, to which he gives (with doubtful propriety) the name of subclasses, and then divides these sub-classes into families, characterized in the main by modifications of the frame work, as well as by the character of the odontophore, teeth, and pedicillaria.

The first sub-class includes the typical star-fishes and related types, as the Asteriadæ, Heliasteridæ, and Brisingidæ, which have, as common characters, the mouth of the ambulacral type; pedicilaria pedunculate, and straight or claw shaped, and the ambulacra generally in four rows. The second sub-class is richest in representatives, and these have a mouth of the adambulacral type, the pedicellaria sessile and valvular, and the ambulacra are always biserial. Seven families are distinguished by the names *Echinasteridæ*, *Linckiadæ*, *Goniasteridæ*, *Asterinidæ*, *Pterasteridæ*, *Astropectinidæ*, and *Archasteridæ*.

A GENERALIZED STAR-FISH.

A form of star-fish (using the word in its broadest sense) has been found in the sea about Madagascar, which is remarkable for certain of its characters, for although in truth an ophiuroid, it exhibits some features approximating it to the asteroids. According to the describer (Mr. W. Percy Sladen),* indeed, the characters of Asteroidea and Ophiuroidea are combined in singular manner. The disk is enlarged and pentagonal and the rays singularly abbreviated and aborted, so that the form is very unlike an ordinary ophiuroid. In fact the arms are for the greater part of their length inclosed in a disk formed of calcareous plates both above and below, but only a small portion of jointed arm projects from each angle of the pentagon thus formed, and, with the structure along the lines of the arms on the lower surface, reminds one of the ophiurids. It is contended that the whole skeleton structure is due to the abnormal development of the ordinary plates of the ophiurid, but at the same time in the structure of the animal a number of characters are observable which tend toward the asteroids, such as a great development of the ambulacral system, with formation of supplementary plates separating the tentacular compartments, the extension of the peritoneal cavity into the radial portions of the animal, and the organization of the mouth.

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* Viguier (C.). Anatomie comparée du squelette des Stellérides, in *Archives Zool. expérim.*, t. vii, pp. 32–250.

* Sladen (W. P.). On the Structure of Asthrophiura, a new and aberrant genus of Echinodermata. *Ann. Mag. Nat. Hist.* (5,) vol. iv, pp. 401–415, pl. 20.

Mr. Sladen concludes with some general remarks on the characteristics and relations of this new type. He argues that "the pentagonal flattened gonio-discoid body, combining within its area representatives of the whole free radial system, as well as of the disk of the typical Ophiuran, presents us with nothing less than the anomaly of an organism having ophiuroid ray-plates expanded and then consolidated along with their disk into a pentagonal asteroid form of test. Such a remarkable arrangement of the entire brachial series and abnormal development of the side arm-plates is," he says, "so far as I am aware, quite without a parallel amongst the Ophiuroidea, and constitutes a character which I regard as an approach to the structure of the Asteroidea. Although it may be asserted that the resemblance is largely superficial, and that the plates, when taken individually, are truly ophiuroid after all, the objection is counter-balanced by the fact that this combination of radial and interradial systems within a common periphery involves morphologically a principle of much higher import than simply outward form, and to which testimony is borne, more or less fully, by each of the following particulars, that is, (1) "the limitation of the tentacular pore-system to the disk"; (2) "the extremely rudimentary condition and aborted character of that portion of the radial series which is prolonged beyond the body-disk, and which seem to give indications of disuse and cessation of function in this area of Ophiuroid organization, followed by a localization of function according to the plan of Asteroid organization"; (3) "the extraordinary development of the tentacular or ambulacral system as compared with its usual standing in Ophiurian anatomy, together with a most extreme modification of the muscular system characteristic of that group," indicating unequivocally a tendency toward the growth of Asteroid characters; (4) "the prolongation of the peritoneal cavity into the radial portion of the animal," evincing "a divergence towards a structure usual in the Asteroid group"; (5) the simple and rudimentary character of the mouth armature," which differs from the ophiuroid and approximates the asteroid type; and (6) "the aborted character of the axis or internal arm-skeleton." In fine, the characteristics of the new type are such as to isolate it, at least with family value, from all the other Ophiuroids, and this is established under the name "*Astrophiuridæ*," by Mr. Sladen, with the following characteristics:

The arms, with an Ophiuroid disk, included in a pentagonal body; the teeth absent; the armature of the mouth simple and imperfect; the pores for the ambulacral feet separated by narrow septa, which are perpendicular to the rays; the interbrachial cavity very broad.

WORMS AND WORM-LIKE ANIMALS.

MODIFICATIONS OF WORM-TYPE.

The arrangement of worm-like animals in the *systema naturæ* has taxed the learning and ingenuity of naturalists to a high degree, and especially during the last quarter of a century. Within the last two years several attempts have been submitted, exhibiting the widest diversities from each other. Whatever may be the ultimate verdict, it is quite certain that there is no concurrence now as to the value of the characters used to distinguish the various groups. As an indication of some of the tendencies in the taxonomy of the types in question, several of the systematic expositions are noteworthy.

Mr. A. Giard, in connection with a communication on the Orthonectids, gives his peculiar views of the worm-like animals.*

The name VERMES is accepted as the designation of a "sub-kingdom" which includes Orthonectids, Dicyemida, Trematoda, Cestoda, and Turbellaria.

The name GYMNOTOCA is suggested for the "Annelida and associated groups," as well as the Bryozoa, and also the true Mollusca. (The Tunicata, he thinks, "must be placed at the foot of the sub-kingdom Vertebrata.")

The designation NEMATELMIA is used for the Nematoida, Echinorhyncha, Desmoscolecida, Gastrotricha, &c.

THE INTESTINAL WORMS OF THE HORSE OF DENMARK.

Dr. H. Krabbe has investigated the relative frequency of occurrence of different entozoa of the intestinal canal of the horse in Denmark.† The following is the ratio to the hundred for the different species ascertained, which are six in number, namely:

	Times.
Tænia perfoliata	28
" *mamillana*	8

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* Giard (A.). The Orthonectida, a new class of the Phylum of the Worms. *Quart. Jour. Micr. Sci.*, vol. xx., pp. 225–240.

† Krabbe (H.). Researches on the occurrence of Intestinal Worms in the intestinal canal of the Horse. *Ann. Mag. Nat. Hist.*, (5,) vol. vi, pp. 96, 97.

	Times.
Ascaris megalocephala	16
Strongylus armatus	86
" *tetracanthus* (in 67 out of 86 horses)	78
Oxyuris curvula	2

A NEW TYPE OF PARASITIC WORMS.

Surgeon-Major G. E. Dobson has recently made known a remarkable parasitic worm found in the intestine of an African bat (*Megaderma frons*). This has lately been examined by Dr. J. D. McDonald* as well as by Surgeon Dobson. The former remarks that at first he agreed with Surgeon Dobson in thinking that it represented a new order of Annelids, but he is now disposed to look upon it as a new type, whose alliance is rather with the Nematoda. Surgeon Dobson considers it as the type of a new order of worms, which he calls Metabdellada, and which he refers to the "Archæostomata," among which, it is to be interposed between the Rotifers and the Trematods.

THE CLASS OF ORTHONECTIDS.†

In 1877 Mr. A. Giard, of Paris, described some parasitic animals of very low organization as the constituents of a peculiar class to which he gave the name Orthonectida. These Orthonectida present, as a permanent feature of their existence, the planula-form, which is one of the embryological stages of most animals. They occur as parasites in Nemerteans and Ophiuroids. Mr. Giard has since supplemented his original observations and studied their reproduction. Their movements, independent of vibratile cilia, are due to the presence of muscle-like bands belonging to the endodermic cells and forming a splanchno-pleural "pseudo-mesoderm." Reproduction is effected in two ways: (1) sexually and (2) by gemmiparity. In the former course it is (*a*) by the formation of a *blastula* or (*b*) by the production of an *epibolic gastrula* which finally closes, and, in both cases, there ensues a permanent *planula* state with a metamerized ectoderm. In the latter course gemmiparity supervenes in the interior of enormous sporocysts formed by the endoderm of the progenitve animal. It is as a result of gemmiparity that the Orthonectids are met with in abundance in their host. The Orthonectids, it is concluded, "are Gastræada brought by parasitism to the state of *planula*," and their importance on the "Gastræa theory" is very great. (See, also, Metschnikoff in *Zool. Anzeiger*, vol. ii, p. 547.)

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*Macdonald (John Denis). On the anatomy of a new parasitic worm found in the intestine of a bat (Megaderma frons). *Ann. Mag. Nat. Hist.*, (5,) vol. vi, pp. 409–411, pl. 21. Also, Dobson (G. E.). Note on Pterogodermatites Macdonaldii; the type of a new order of Vermes. *Ann. Mag. Nat. Hist.* (5), vol. vi, pp. 412–414.

† Giard (A.). On the organization and classification of the Orthonectids. *Ann. and Mag. Nat. Hist.*, (5,) vol. iv, pp. 471–473. From *Comptes Rendus*, September 22, 1879.

A NEW PRIMITIVE TYPE OF WORMS.*

The genus *Polygordius* has been supposed to represent one of the most primitive forms of Annelids, but in 1880 Dr. Hatschek made known a species which seems to be still more simple in its organization, and therefore to exhibit the most archaic form in which the Annelidan structure is known to exist at the present day. This new form has been named *Protodrilus Leuckarti*, and was found near Messina. The inferiority of its organization is manifest especially in the nervous system, the ventral ciliary groove, the blood vascular system, and the intestine. The muscular system resembles that of *Polygordius*. "The nervous system is difficult to make out in the living object, the ganglionic nature of the frontal ganglion being indistinguishable and the presence of the organ merely indicated by a thickening of the integument; the sensory organs are represented by two transverse, elongated, ciliated slits, placed on the dorsal surface of the anterior portion of the head. There are no pigmented eyes." The intestine has no rectal division. "Just behind the mouth there opens into the œsophagus a muscular organ of a complicated form, and terminating blindly in a chitinous vesicle very similar to the same organ in *Polygordius;* it has a function which still remains to be discovered." (Condensed from *J. R. M. S.*, vol. iii, pp. 791–792.)

POLYGORDIUS AND ITS RELATIONS TO OTHER WORMS.

A worm-like form that has excited much interest and has been regarded as the most primitive of Annelids is the genus *Polygordius*. What is now known to be the larva of this form has been long known, and had excited considerable speculation, but its parentage was discovered but lately. Dr. Hatschek has been able to verify the developmental stages of this type,† and has recognized six: (1) That prior to segmentation, when the embryo is small and transparent, broader than long, and divided into two parts by two parallel circlets of cilia in the middle line, with the mouth placed between these and the arms, and the latter opening at the inferior pole of the body, and with two eye spots above; (2) the primitive segments of the body appear, the mesoderm is further developed, as is also the posterior circlet of cilia; (3) the larva becomes elongated, differentiation of the ventral cord and antennæ ensues, and a ciliated pit supervenes on either side of the head, and represents apparently the future olfactory organ; (4) the walls of the enteric cavity become strengthened by the apposition of the proper division of the mesoderm, and the posterior circlet of cilia becomes greatly developed; (5) the cuticle of the trunk becomes thicker, and the region of the head becomes much more like what it will be in the adult, while its circlets of cilia begin to disappear; (6) two distinct regions become apparent in the head, the tentacles become prominent, the walls of the mid-gut are considerably thickened; and there is still a mass of rounded, indifferent cells, which appear to be the rudiments of the generative products.

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* Hatschek (B.). Protodrilus Leuckartii, eine neue Gattung der Archiannelides. *Arb. Zool. Inst. Wien*, vol. iii, pp. 79–92, with 2 pl.

† Hatschek in *Jour. Roy. Micr. Soc.*, vol. ii, pp. 563–567. Also, Giard (A.). Sur les affinités du genre *Polygordius* avec les Annélides de la famille des Opheliidæ. *Comptes Rendus Ac. Sci.* Paris, vol. xci, pp. 341–343. (Translated in *Ann. Mag. Nat. Hist.*, (5,) vol. vi, pp. 324–326.)

Taking these different stages of development into consideration, Dr. Hatschek indorses the view that *Polygordius* is an Annelid, although it manifests many points in adult structure which are merely embryonic in other forms. *Polygordius* thus represents what may be designated Archi-Annelids or primitive Annelids, and its affiliations with the other types are indicated as follows:

Annelides.

First order, *Polygordiidæ.*
Second order, *Chætopoda.*
    First suborder, *Saccocinidæ.*
    Second suborder, *Polychæta.*
    Third suborder, *Oligochæta.*
Third order, *Hirudinea.*
Fourth order, *Gephyrea.*

(Condensed from *J. R. M. S.*, vol. ii, pp. 563–567.)

PLATYHELMINTHES.

PARASITIC PLANARIANS.

Inasmuch as extremely few parasitic Planarians have been hitherto recognized, the discovery by Dr. von Ihering of one which occurs in the kidney of *Murex* is noteworthy.* The new form has been called *Graffilla muricicola*, and is easily perceptible in that organ by its reddish-brown coloration. It attains a length of about 5 millimeters, and is distinguished by the development of a thick anterior and narrow tail-like posterior region, quite distinctly marked off from each other. But the most prominent characteristic of *Graffilla* is the structure of the pharnyx; this is not provided with a special sac or pouch, and in this respect the new form is distinguished from all similar species, and is therefore made not only the type of a distinct family, but a distinct group of Rhabdocœla. These it is proposed to divide into (1) such as have a pharynx (*Pharyngea*), and (2) such as are deprived of a pharynx (*Apharyngea*). To the former group the Graffillidæ belong; but, as already indicated, they are differentiated from all the other Pharyngea by the absence of a special pharyngeal pouch, and therefore stand in a section apart from the rest.

Another parasitic Planarian has been found by Dr. Arnold Lang in the foot of *Tethys*,[*] but at the same time it is conjectured that it does not reside there permanently. This form has not been named, but has been considered to be closely allied to *Graffilla muricicola*. The pharynx was feebly developed and appeared to be destitute of a sheath. No peripheral nerves or special organs of sense or water-vessels were observed. The female organs were well developed; but in none of the specimens examined could the male organs be detected except in a rudimentary condition.

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* Ihering (H. von). Graffilla muricicola, eine parasitische Rhabdocœle. *Zeitschr. f. Wiss. Zool.*, vol. xxxiv, pp. 147–174.

THE GROUPS OF NEMERTEAN WORMS.

The Nemertean worms have been examined with relation to their genera and systematic relations *inter se* by Dr. A. A. W. Hubrecht.[†] It is claimed that the genera proposed for the European forms must be reduced to fourteen. These are grouped, first, into two sections, one distinguished (*Hoplonemertini*) by the mouth being in front of the ganglia and the proboscis furnished with stylets, and the second (*nameless*) by the mouth situated behind the ganglia and the proboscis destitute of stylets. The latter are subdivided into (1) *Schizonemertini*, distinguished by the development of a deep lateral fissure on both sides of the head; and (2) *Palæonemertini*, characterized by the absence of such fissures. The three groups so named are designated as "*suborders.*"

The suborders are essentially the same as the three families generally admitted, and which are much better so designated than as suborders. The genera admitted are segregated under nine families, and are, for (1) the Hoplonemertini, *Nemertes*, *Oerstedia*, *Prosorhochmus*, *Tetrastemma*, *Amphiporus*, and *Drepanophorus;* in (2) the Schizonemertini, *Langia*, *Cerebratulus*, *Borlasia*, and *Lineus*, and in (3) the Palæonemertini, *Valencinia*, *Polia*, *Cephalothrix*, and *Carinella*. (Condensed from *J. R. M. S.*)

The author seeks to determine the phylogeny of these forms, but the data apparently are not sufficient for such purpose.

A PARASITIC NEMERTEAN.

More than a century ago (in 1779) O. F. Müller described a worm which has, until lately, been regarded as being a kind of leech. This form has been named *Malacobdella grossa*, and the specimens occur parasitic in *Cyprina Islandica*. As indicated by the name, *Malacobdella* is characterized by a very soft body, and its width is nearly the same as the length, except in the region of the sucker; its muscular system is characteristic; the mouth is placed at the anterior end and is a transverse cleft; the proboscis is white, and is destitute of any armature or spines; the pharynx very white and visible through the transparent integument; the intestine narrow and dark. On account of this union of characters by which it contrasts with all the three previously recognized families, Von Kennel has lately proposed to isolate it as the type of an independent one. This family (*Malacobdellidæ*) is distinguished by "the dermo-muscular layer arranged in an external, circular or an internal longitudinal layer; the absence of spines to the proboscis; the non-development of cephalic grooves or lateral organs; the intestine simple and forming several coils; the nerve-trunks free from the muscular system and united posteriorly by an anal commissure, and the development of a sucker at the posterior end."*

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[*] Lang (Arnold). Notiz über einen neuen Parasiten der Tethys aus der Abtheilung der rhabdocoelen Turbellarien. *Mittheil. Zool. Station Neapel*, vol. ii, pp. 107–112.

[†] Hubrecht (A. A.W.). The Genera of European Nemerteans critically revised, with descriptions of several new species. *Notes Mus. Leyden*, No. iv, pp. 193–223.

CHÆTOGNATHA.

RELATIONS OF THE CHÆTOGNATHA.

A form that derives considerable interest from the speculations that have been entertained about it by the earlier naturalists, is the worm group known as *Sagitta*, and for which the order Chætognatha has been instituted. An elaborate monograph of this order has been published by Dr. Hertwig during the past year, and he has especially inquired into the subject of its relationship with other types.† He recalls the investigations of Kowalevsky and the application by Huxley of the condition of the body cavity to taxonomy, and rehearses that in most animals this cœlom is formed by a cleavage of the mesoblast (schizocœle), and that in others—as in the Echinoderms, Brachiopods, and Amphioxus—the cœlom is developed from outgrowths of the endoblast (enterocœle). It is the latter type that is manifested in the Chætognatha. The Chætognatha are said to be most nearly related to the Nematoids and Annelids, and the relations to the latter are claimed to be very remarkable. In both "the enteron is invested in a fibrous enteric layer, and is attached by mesenteries which completely divide the cœlom into a right and left half. In both cases there are four bands of longitudinal muscular fibers, the cells of which are derived from the cœlomatic surface. The two transverse septa of the Chætognatha are comparable to the numerous transverse septa in the Annelids, while, lastly, in both groups the generative products are derived from cells of the parietal layer of the mesoderm." The olfactory organ is on the upper surface of the head near the eye and behind the supra-œsophageal ganglion, and is unpaired and very simple in character.

The nervous system is noteworthy, the chief ganglia and their nerves being embedded in the epidermis, while some smaller cephalic ganglia belong to the mesoderm; or, in other words, the nervous system is differentiated into ectodermal and mesodermal parts. To the former there are two central organs, the supra-œsophageal and the ventral ganglia. In the latter are developed a lateral cephalic ganglion and two other small ganglia.

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* Kennel (V.). *Arbeit. Zool. Zoot. Inst.* Würzburg, vol. iv, p. 305, 1878.

† Hertwig (O.). Die Chætognathen. *Studien zur Blättertheorie*, Heft ii, Jena, 1880, 6 pl.

The taxonomical deductions are that the Chætognatha form a group characterized by the "body consisting of three segments, separated by septa and provided with horizontal fins; the head with prehensile hooks, spines, and a 'cap,' with two eyes, and an unpaired olfactory organ; cœlom spacious: the enteron has two mesenteries and opens in front of the aventerous caudal segment; four longitudinal muscular bands: nervous system consists of the ventral, the supra-œsophageal, and the lateral cephalic ganglia: trunk segment with two ovaries; caudal segment with two testes.—In this group are recognized two modifications of generic value, one (*Sagitta*) having an unpaired caudal and *two* pairs of lateral fins, including ten species, and the other (*Spadella*) with an unpaired caudal fin and *one* pair of lateral fins, including three species. (Condensed from *J. R. M. S.*, vol. iii, pp. 793–799.)

PERIPATIDEANS.

ON THE RELATIONS OF PERIPATUS.

Until lately there has been no difficulty in trenchantly separating the arthropods from the vermiform articulates, but in Peripatus (a terrestrial worm-like animal of tropical countries) we have a form that is at once to some extent intermediate between the two, and that breaks down the rigorous diagnoses of those great groups and forbids the neatness and precision of definition formerly accorded to them. On the one hand *Peripatus* possesses quite a well-developed tracheal system and therein agrees with the terrestrial arthropods. On the other hand it agrees with the worms in that the segment at organs are in all essential respects like those of the Vermes and especially of the leeches, each organ consisting of a coiled glandular tube connected at one end with a short tube of somewhat different character, and probably opening into the body cavity, and at the other end dilating into a vesicle that debouches on the surface of the body at the base of the corresponding foot. Mr. Balfour has now called attention to a new feature in the economy of the animal which throws some light on its relationships.* There is a gland which has a duct opening into the mouth, and which is comparable with the salivary gland of the centipedes. (It has generally been considered as a "fat-body.") Now, salivary glands are distinctive of the Tracheate Arthropods, and are not at all represented in the worms; we have therefore in this structure of *Peripatus* another indication of its relationship with the Arthropods. By recent authors *Peripatus* had been distinguished as the type of a primary group under the name Protracheata, and the data thus indicated are worthy of attention in connection with its place in the system.

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* Balfour (F. M.) on certain points in the Anatomy of Peripatus Capensis. *Proc. Cambridge Phil. Soc.*, vol. iii, p. 6, 1879.

MEROSTOMES OR PALÆOCARIDS.

THE EYES OF THE HORSESHOE CRABS AND TRILOBITES.*

Professor Packard has investigated the structure of the eyes of the horseshoe crab, and, in connection therewith, that of the corresponding organ of the Trilobites. In the eye of the horseshoe crab (*Limulus*) the cornea is developed as "a thinned portion of the integument"; on each side are "nutrient" or pore canals, which are filled with connective tissue, extending into the integument from the body cavity. Apposed to the transparent cornea, and arranged in quincuncial order, are series of solid conical lenses, of which the conical ends project inwards and are partly buried in the black retina. "The long slender optic nerve, just before reaching the eye, subdivides, sending a branch to each facet or cornea impinging on the lens." As this is a unique condition of the eyes in living articulates, it was an interesting problem to discover whether the affinities of the Trilobites with *Limulus* was manifested in this as in other respects. Casts and natural sections of *Asaphus gigas* especially were examined, and when the concave or interior surface was placed under a magnifying power of 50 diameters, the entire surface was seen to be rough, with the ends of the minute solid conic corneal lenses which projected into the body cavity. "This is exactly comparable with the cast shell of *Limulus* and its solid corneal lenses which project into the body cavity."

CRUSTACEANS.

ABORTED DEVELOPMENT IN CRUSTACEANS.

It has long been recognized that while forms inhabiting the sea pass through several stages of metamorphoses, species quite closely related, living in fresh water, do not exhibit similar stages in their development. The forms that so deviate from the general manifestations in the class are always of interest, and Dr. Fritz Müller has examined from this point of view several Brazilian decapod crustaceans.† He found that *Trichodactylus* and *Aeglea Odebrechtii* failed to pass through the regular crustacean metamorphosis, and that the female of *Palæmon potiuna* produces only 6 to 20 large eggs, and from these the young emerge with the superficial characteristics of the adults, whose complete form they assume at the fourth change of skin. But what is still more noteworthy is that while *Hippolyte polaris* passes through a shortened phase of development, on the other hand a Brazilian *Hippolyte*, closely related to that species, was ascertained to emerge from the egg as a zoœa. Several fresh-water shrimps also found at the mouth of the Itajahy River—a *Leander*, a *Palæmon*, and one of the *Atyinæ*—also come from the egg as zoœæ.

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*Packard, jr. (A. S.). The Structure of the Eye of Trilobites. *Am. Nat.*, vol. cxiv, pp. 503–508, July, 1880.

†Müller (Fritz). Palæmon potiuna; ein Beispiel abgekürtzer Verhandlung. *Zool. Anz.*, vol. iii, pp. 152–157 (223).

INSECTS.

SCOLOPENDRELLA, THE TYPE OF A NEW ORDER OF MYRIOPODS.

The genus *Scolopendrella* has recently been re-examined by Mr. John A. Ryder,* and he has found some remarkable peculiarities in its organization, which, in his opinion, entitle it to be differentiated as the representative of a distinct order of Myriopods. The characteristics, according to Mr. Ryder, "indicate as much affinity with insects as with myriopods, and may, indeed, be looked upon, perhaps, as representing the last survival of the form from which insects may be supposed to have descended." The head is essentially like that of a true insect, and the epicranial pieces are distinguished by well-marked suture from the labrum. The labrum and labium are both well defined; mandibles and maxillæ are developed, as well as, apparently, a ligula. The antennæ have numerous (14 to 28) articulations. The body proper has thirteen segments. The legs (in number 12 or less) are five-jointed, and each terminated by a pair of claws, as in the typical insects, and at the bases of each pair, except the first, are attached simple hairy appendages. The genital orifice is on the ventral side, in the third or fourth body segment, in both sexes. The tracheal system is represented by a series of simple tubular arches, without a spiral filament, arising from openings on the ventral surface inside the base of the legs. Of this combination of characteristics not the least noteworthy are the biunguiculate legs, and their nearly complete correspondence in number with the rudimentary abdominal and functional thoracic limbs of the Thysanura, especially *Machelis* and *Lepisma*, which have also basal appendages to the legs; it is these characteristics that point to the affinity with Insects almost as intimate as that with the Myriopods. The order thus distinguished has been named *Symphyla*, in reference to the singular combination of characters presented. It may be added that this order has already been adopted by a special student of the Myriopods, Latzel having accepted it in his lately published work on the Myriopods of the Austro-Hungarian monarchy. Whether it will be hereafter associated most intimately with the typical Myriopods or Insects, remains to be seen; but it is at any rate certain now that these two types cannot be retained as full classes.

INSECTS INJURIOUS TO BOOKS.

The question of injuries incurred by books from the attacks of insects has been examined into by Dr. Hagen,† and Professor Westwood. Representatives of not less than six orders of Arthropods are more or less injurious.

Among the mites is the common *Cheyletus eruditus*, which attacks paper in damp places.

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* Ryder (John). Scolopendrella as the type of a new order of Articulates. *Am. Nat.*, vol. xiv, pp. 375, 376.

† Hagen (H.). Attacks of Insects on Books. *Jour. Roy. Micr. Soc.*, vol. iii, p. 422.

University of Michigan Library

Among the Thysanura, the *Lepisma saccharina*, which is found in closets, &c., where provisions are kept, feeds also on paper, but leaves untouched that which is covered by printing-ink. This species was not known till lately to be at all injurious to paper or books.

Of the Neuroptera, the termites are injurious to paper and books as well as to many other substances.

Of the Orthoptera, as is well known, the cockroaches (Blattidæ) frequently commit considerable ravages.

Of the Lepidoptera the caterpillars of *Aglossa pinguinalis* and *Depressaria* frequently do damage by spinning their webs between the volumes, and also by gnawing the paper with which they form their cocoons.

Among the beetles are several species. The *Hypothenemus eruditus*, a very minute species, excavates tiny burrows within the binding. The death-watches (*Anobium pertinax* and *Anobium striatum*) surpass in their ravages all other species, gnawing and boring not only through the pages of the volumes, but also through the binding. One instance is recorded where 27 folio volumes, placed together on a shelf, had been so completely drilled, that a string might be run through the hole made.

As an antidote to and preventive of the attacks of these insects, vaporization is suggested. The infected volumes may be placed in a large glass case made as close as possible, and therein likewise may be set small saucers containing benzine, or a sponge saturated with carbolic acid. "A strong infusion of colocynth and quassia, chloroform, spirits of turpentine, expressed juice of green walnuts, and pyroligneous acid have also been employed successfully. Fumigation on a large scale may also be adopted, by filling the room with fumes of brimstone, prussic acid, or benzine; or an infected volume may be placed under the bell-glass of an air-pump, and extracting the air, the larvæ will be found to be killed after an hour's exhaustion."[*]

DESTRUCTION OF INSECTS BY FUNGI.

It may be recalled that at the Portland (1873) meeting of the American Association for the Advancement of Science, Dr. Le Conte suggested that an efficient mode of checking the devastations of the insects injurious to agriculture might be the "production of diseases" from parasitic fungous growths. He mentioned, without particularizing, "an instance in which from the communication of the disease by some silk-worms, the whole of the caterpillars in a nine-acre piece of woods were destroyed." The same proposition has been entertained and advocated by various other writers, for example, Hagen, Bail, &c.

Experiments have been made upon various forms, and lately on potato-beetles. Those inoculated with the fungous disease died in from eight to twelve days, while others in the same room, but which were not so treated, lived through the winter. Plant-lice were killed in a hot-house by similar means. Dr. Hagen therefore contends against Professor Metschnikoff, that fungous inoculation can be applied to practical uses, and that it will not be necessary to wait till the scientific meaning of the phenomena involved is understood; he thinks that the plan has already been successful in practice, although further experiments should be made before any positive decision can be arrived at.

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[*] Hagen (H.). Schädliche Insecten durch den Hefenpilz zu tödter. *Zool. Anz.*, vol. iii, p. 185.—The Destruction of Insect pests by application of yeast. *Nature*, vol. xxi, p. 611.

THE GLOWWORMS AND THEIR PHOSPHORESCENCE.

The structure of the Lampyridæ and their phosphorescent characteristics have been examined by Rev. H. S. Gorham.* The conclusion is reached that "the sexual instinct has played a large part in molding the external structure of this group of beetles, and that it is to that we must look for an adequate explanation of the development of phosphorescent light, though not perhaps for its origin." The cases in which both of the sexes have wings, and both exhibit also phosphorescent qualities, form the larger proportion among existing species. It is contended that in this condition the emission of light would be useful in the attraction of the respective sexes and bring them together in swarms. Those species, however, which are regarded as being the most typical of the family and in which the parts are more specialized, are such forms as *Lamprocera* and *Cladodes*. In these types the phosphorescent faculty has not been developed in the same proportion as the organs generally, and the eyes, for example, are "reduced in a direct ratio with the light" whenever the antennæ are enlarged in inverse ratio to the diminution of the phosphorescence. Whether the eyes develop at the expense of the antennæ, and are, so to speak, the receptacle of all the vital forces of the head, or whether the antennæ supplement the loss of the other organs of sense, and are useful in detecting the presence of the female, only one fact is in evidence, which is that the plumosity of the antennæ, in one case, and the enormous development of the eye, in the other, are usually sexual characters predominating in the male, but sometimes found in both sexes. Mr. Gorham has found that selected species of Lampyridæ may be grouped under three categories, viz:

1. Species with plumose antennæ, small or moderate eyes, both sexes winged, light-emitting surface confined to one or more small spots: *Lamprocera*, *Cladodes*, *Vesta*, *Lucidora*, *Phœnolis*, and *Megalophthalmus*.

2. Species in which both sexes are winged; light emitted considerable, sometimes greater in the ♀; eyes large, sometimes excessive; antennæ simple, usually filiform: *Cratomorphus*, *Lucernula*, *Aspidasoma*, *Luciola*, and *Photuris*.

3. Species in which the female is apterous, or with rudimentary wings; light emitted often very great in the female, and often only rudiment-

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* Gorham (H. S.). On the structure of the Lampyridæ, with reference to their phosphorescence. *Trans. Entomological Soc.*, London, 1880. pp. 63–67.

ary traces of it in the male; antennæ usually rudimentary; eyes large in the male, often excessively so, occupying nearly the whole head: *Pleotomus*, *Lamprophorus*, *Microphotus*, *Lampyris*, and *Lamprorhiza*. (Condensed from *J. R. M. S.*, vol. iii, pp. 777–779.)

POLYZOANS.

RELATIONS OF THE POLYZOANS.

The Polyzoans form a type which, in the early days of zoölogy, was regarded as a class of the radiate animals. Subsequently Milne Edwards and others agreed that the type was most closely related to the Brachiopods, and subsequent investigation of the embryology of the two types confirmed this view. The question afterward came up as to the relationship of both these types to others. Until quite recently it was disputed by no one that the Brachiopods were true mollusks, but when anatomical and morphological investigations had revealed so many differences they were dissociated from the typical mollusks and segregated with the Tunicates under the name Molluscoidea. Later Morse claimed that the two classes in question were more closely related to the worms than to the mollusks. Professor Allman has recently reviewed the condition of our knowledge of the endoproctal Polyzoa,* and confesses that while he still supports the molluscan relationships of the type, he was nevertheless obliged to confess that there were features in which it closely approximated the worms. Among the most significant of these is the existence of a pair of symmetrically placed gland-like organs which open on the surface of the body in *Loxosoma*, and remind one of the segmental organs of the worms. In 187– Professor Nitzsch proposed to differentiate the Polyzoans into two groups, distinguished by the opening of the anal cavity in one case outside of the tentacular crown, and in the other case within the same. The former group was named *Ectoprocta* and included almost all the known forms. The latter group was named *Endoprocta*, and was at first framed specially for *Pedicillina*, but subsequently it was ascertained that not only *Pedicillina* but *Urnatella* and *Loxosoma* also exhibited the same characteristic; and Professor Busk has lately made known a curious form, to which he has given the name *Ascopodaria*, found in the voyage of the Challenger in deep water. It is the *Endoprocta*, according to Professor Allman, that exhibit the closest connection with the vermes. *Loxosoma*, it may be added, is a parasite of Gephyreans, and attaches itself so firmly to the host that before *Loxosoma* had been described Mr. A. M. Norman was led thereby to attribute its crown to a Gephyrean as tentacular appendages of the tail of that worm.

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*Allman (G. J.). Some recent additions to our knowledge of the structure of the Marine Polyzoa. *Jour. Linn. Soc. Zool.*, vol. xv, pp. 1–8.

BRACHIOPODS.

RANGE IN DEPTH OF LIVING BRACHIOPODS.

Mr. Thomas Davidson has examined the collection of Brachiopods secured by H. M. S. Challenger, and in connection therewith has enumerated all the existing species of the class.* It was thought that many novel forms would be obtained by the dredge from the depths of the sea, but this anticipation has not been realized. Very few new species were found during the voyage of the Challenger, and none representing genera that had not before been known from representatives living in waters of less depth. One hundred and thirty-six living species or sub-species are recognized by Mr. Davidson, 125 so-termed "species," and 11 "named varieties"; but, it is added by Mr. Davidson, the number "will certainly have to be hereafter reduced." Not more than 31 species were obtained by the Challenger expedition, and out of 361 stations at which dredgings were made Brachiopoda "were brought up 38 or 39 times only." The circumstances respecting the discovery of 107 of the recognized named forms have been ascertained, while "nothing is known respecting the ranges of depths of some 25 or 26 so-called species." Of the 107 species (or named varieties) some 57, or about half the known species, were dredged at a depth of under 100 fathoms; 20 to 25 at low-water mark, or from 5 to 10 fathoms; and the remainder at about 50 or 60 fathoms," or, to be more definite, the status of our information may be given in the following table:

	Species.
From shore to 500 fathoms some	98
or named varieties; 12 of these range up to 100 fathoms or less.	
From 501 to 1,000 fathoms	16
Of these only one, *Disceria Atlantica*, would range from 690 to 2,400 fathoms.	
From 1,001 to 1,500 fathoms	6
Of these *Terebratula wyvillii* ranges from 1,035 to 2,900 fathoms, the greatest depth at which any species has been found.	
From 1,501 to 2,000 fathoms	4
From 2,001 to 2,900	3

Mr. Davidson concludes that "these facts indicate that the greater bulk of known species live at comparatively small or moderate depths, few in depths ranging up to 500 fathoms, and that Brachiopoda are specifically rare at depths varying from 500 to 2,900 fathoms.

It is to be regretted that Mr. Davidson still clings to the names Clistenterata and Tretenterata when exactly the same groups with the same limits, and the same essential diagnoses, had received each several names long before. If any objections are urged against those previous names, analogous objections can readily be devised against those adopted, and there is nothing easier than to devise objections when the mood impels to seek for new names.

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*Davidson (Thomas). Report on the Scientific Results of the Voyage of H. M. S. Challenger, during the years 1873–'76. Zoology, vol. i, part 1. Report on the Brachiopods. Printed by order of Her Majesty's Government, London, 1880.

ANCIENT LINGULIDÆ.

In the early days of Palæontology the name *Lingula* was applied as the generic designation of numerous species certainly related to the living representatives of that genus but distinct in many respects. Of late years, however, as is remarked by Mr. Whitfield,* "it has been supposed by many that the Brachiopodous genus *Lingula*, as represented by *Lingula anatina* Lamarck, a living species, was not represented among the fossil Lingulidae of the older Paleozoic formations, if anywhere in rocks of paleozoic age; and there has been a growing tendency to class all Linguloid shells of these formations under other names." While this is admitted to be correct in the main, by Mr. Whitfield, he thinks that he has proof of a form congeneric with or at least closely related to the modern species, in shells obtained from the Trenton limestones of Wisconsin and Minnesota. He has carefully studied the muscular and vascular scars of the shell as copied in their internal casts, and thinks that "these markings correspond more nearly to those of *L. anatina* Lamarck, than do those of any other Silurian or Devonian species" which he ever examined, and, "although they do not exactly correspond, still are as similar as one could expect in widely separated species. The variations consist in the position of the various muscular scars, and also somewhat in the lines of the pallial sinuses and in the ramifications of their branches." Without going into detail it is enough to remark that there certainly seems to be considerable superficial resemblance between the form thus signalized and the living representatives of the family. Nevertheless the homologies are far from being as close as those which prevail in all the living forms, and which, notwithstanding, have been differentiated under two distinct genera, *Lingula* and *Glottidia.* In view of the great antiquity of the type, however, even the resemblance, though not very close, is noteworthy. Whether the resemblance is a generic one (using the word "generic" in the restricted signification) is doubtful.

GASTROPODS.

A NEW TYPE OF MOLLUSKS.

A most singular type of Mollusks, and one finding no place in the current works on conchology, is the genus *Neomenia* of Tullberg (*Solenopus* D. & K.). This is the representative of not only a distinct family (Neomeniidæ) but of a group which stands so far apart from all others as to leave even its relationship a matter of discussion. G. O. Sars distinguishes it as a group (Telobranchiata) of the Opisthobranchiates, co-ordinate with the Tectibranchiata and Nudibranchiata. H. von Ihering differentiates it as a class of "Vermes—Phylum Amphineura," the Chitons forming another class. E. Ray Lankester isolates it still further, considering it as representing not only a class (Scolecomorpha) but a primary group (Lipoglossa) of Mollusks having no affinity to the Chitons. A new form of this group, exhibiting characters, too, deemed wanting in the type, must be of unusual interest. Such is the species made known as *Proneomenia Sluiteri.** Like *Neomenia*, *Proneomenia* is worm-like and subcylindrical, but unlike that form it is provided with a distinct though small radula. Two specimens of the species were dredged by Dr. Sluiter in the Barent Sea.

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* Whitfield (R. P.). On the occurrence of the true *Lingula* in the Trenton Limestones. *Am. Jour. Science* (3), vol. xix, pp. 472–475.

REGENERATION OF PARTS IN GASTROPODS.

Long ago Spallanzari and afterwards Schäffer experimented upon the regeneration of parts in snails, but this subject has since been much neglected. Recently Mr. Justus Carrière has reinvestigated the question†, and has found, like his predecessors, that the tentacles, with the eyes and the labial processes in the gastropods, can be completely regenerated. On the other hand, when the pharynx or supra-œsophageal ganglion is cut out death ensues. Mr. Carrière took all precautions in his investigations, and all the conditions to insure accuracy were fulfilled, that is, with respect to the health of the animal, the parts removed, &c., for a different result would ensue if the animal was taken when its energy was concentrated in the formation of generative products, and it was therefore found that a season of rest, as at the beginning of summer, or the autumn season, was the most satisfactory time. The individuals experimented upon represented common European species of *Helix.* Those that gave the most satisfactory result were *Helix nemoralis* and *H. hortensis; H. pomatia* was more sensitive, and *H. arbustarum* and *H. fruticum* the least capable of reproduction of parts.

In the case of the eye it was ascertained that the method of regeneration was analogous to that of the first formation of the organ. There was an invagination of the epithelium, the formation of a closed vesicle, and the primitive cylindrical cells became partly converted into corneal cells, and partly into rods and cones. The time required for this regeneration was fifty or sixty days.

Experiments were also instituted with respect to the aquatic pulmonates, but the results were less satisfactory on account of their liability to attack by fungus in the wounds.

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*Hubrecht (A. A. W.). *Proneomenia Sluiteri* gen. et sp. n., eine neue archaische Molluskenform aus dem Eismeer. *Zool. Anzeiger,* iii Jahrg., pp. 589–590, 29 Nov., 1880.

†Carriere (J.). Ueber die Regeneration bei den Land-Pulmonaten. *Tagblatt der* 52 *Vers. deutsch. Naturf.,* pp. 225, 226. 1879.

GASTROPTERON AND ITS RELATIONS.

A remarkable form of gastropod mollusk, which was at one time supposed to be a Pteropod, has now been well ascertained to be a Tectibranchiate and most closely related to the Bullidea. In general form it has, in fact, considerable resemblance to a Pteropod, and the shell is so small and immersed that it was not detected until Krohn found it in 1860. The shell resembles somewhat that of a *Carinaria* in form, and is quite translucent: it is found in the hepatic region near and somewhat behind, but a little to the right side of, the anus.

Mr. Vayssière has investigated the anatomy of this form, and has reached, in respect to its relation, some conclusions differing from his predecessors.* He regards *Gastropteron* as the type of one of two major groups, into which he would divide the Bullidea, most of the forms of that type constituting the second group.

In this first group represented by *Gastropteron* the parapodia are largely developed: a small nautiloid shell is contained within the mantle; and the œsophageal collar is constituted by a pair of cerebral ganglia, a pair of pedal ones, and six visceral ones; the visceral ganglia are distributed in equal number, three to the right and three to the left.

In the second division the parapodia are rudimentary; the shell well developed and generally external; and there are only three visceral ganglia, two of which are on the right and one on the left side.

It is observed also that while in *Gastropteron* the genital nerve arises directly from the commissure without the intermediation of any ganglionic enlargement, in the other forms the corresponding nerve always arises from the larger of the two left visceral ganglia.

LIVING PLEUROTOMARIIDS.

Among the most interesting of the mollusks is the genus *Pleurotomaria.* This genus was for a long time supposed to have become entirely extinct, but in 1856 a species was discovered at the island of Guadeloupe and named by Fischer and Bernardi *Pleurotomaria Quoyana.* Subsequently a specimen of a second species was also obtained and described under the name of *Pleurotomaria Adansoniana* in 1861. In 1880 further information respecting the development of the genus was obtained. A second specimen of *Pleurotomaria Adansoniana* (91 millimeters wide) was found in the "grand cul de sac de la Point-à-Pitre," Guadeloupe, at a depth of 150 fathoms, and two new species were obtained in the Eastern seas. One has been described by Hilgendorf as *Pleurotomaria Beyrichii*, from a specimen obtained in Japan. Another has been made known as *Pleurotomaria Rumpfii* by Schepman, and the specimen on which it was based (a very large one, having a maximum diameter of 190 millimeters) was found in a collection of shells from the Molucca Islands belonging to the Zoological Garden of Rotterdam. It is noteworthy that these species represent two sections of the genus, one of the species of Guadeloupe (*P. Quoyana*) and one of the eastern (*P. Beyrichii*) having no umbilicus, while the other two, *Pleurotomaria Adansoniana* and *P. Rumpfii* are deeply umbilicated. The soft parts of *Pleurotomaria* are still unknown, although we may hope that our acquaintance with a form so interesting may not be much longer deferred, inasmuch as a living specimen of *P. Quoyana* was obtained by Professor Agassiz off the island of Barbados (at a depth of 120 fathoms), and is now in the Museum of Comparative Anatomy at Cambridge. (See HILGENDORF in Sitzungsberichte der Gesellschaft Naturf. Freunde zu Berlin, 1879, p. 72; SCHEPMAN in Tijdschrift Nederl. Dierkund. Vereen., vol. iv, 1879, p. 162; CROSSE & FISHER in Journal Conchyliologie, (3,) vol. xx, pp. 203, 284, 1880.)

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* Vayssière. Recherches anatomiques sur les mollusques de la famille des Bullidés. *Ann. Sc. Nat., Zool.,* (6,) vol. ix, No. 1 (64 pp., 3 pl.).

DENTITION OF MARGINELLOID MOLLUSKS.

The contour and development of the shell of *Marginella* is quite characteristic, but nevertheless there are now known four distinct types of dentition represented by forms possessing decidedly similar shells, and if the Eratoinæ are considered, we have a fifth.

(1.) As is generally known, most of the species have a single central tooth (o—1—o) with a narrow base, and this has been regarded as being one of the distinctive marks of the family *Marginellidæ*.

(2.) A similar form, however, was shown a number of years ago, by Stimpson, to have a single row of teeth peculiarly modified, resembling those of the Muricinæ, being thick, strong, and armed with many (7) denticles, and was therefore differentiated by him as the type of a peculiar family—*Cystiscidæ*.

(3.) Towards the end of the year 1880 a third type was found to be represented by what has been called *Pseudomarginella leptopus*, and what has been also by some (but erroneously) identified with the "*Marginella glabella*," of Eastern Africa. Shells with their animals were sent from Senegambia, and the species was ascertained to have the teeth arranged in three long longitudinal rows, (1—1—1), and their form very similar to that of the Buccinids, the lateral teeth being broad and armed with three cusps.

(4.) A fourth marginelliform type has also teeth in three series (1—1—1), but the lateral teeth are slender and claw-like. The species representing this has been described by Carrière as new under the name *Pseudomarginella platypus*, and thus systematically arranged with the preceding, with which it is geographically associated. The difference in dentition is, however, generally regarded as of family value.

(5.) Still another marginelloid type, although much more differentiated than any of the others, is represented by *Erato*, which is now generally regarded as a true member of the family of Cypræidæ or Triviidæ.

The manifestation of such different types of dentition by forms having the same kind of shell will render a re-examination of the other parts of the animal necessary before it can be definitely accepted whether they are distantly related, as the current views respecting the value of dentition would imply, or whether they are closely connected, as the likeness of their shells would suggest. In this connection we may refer to the similarity of the shells of the Mitridæ and Turritidæ. While it is not safe to assume that the animals so distinguished are closely related on account of the similarity of their shells, there is enough at least to challenge doubt, which can only be settled by further investigations. (See CROSSE & FISCHER in Journ. Conchyliologie (3,) vol. xx, p. 375, 1880; and JUSTUS CARRIÈRE (Die Gattung Pseudomarginella v. Maltzan), in Zool. Anz., vol. iii, pp. 637–641, 27 Dec., 1880.)

CEPHALOPODS.

THE ARMS AND SIPHON OF CEPHALOPODS.

A number of attempts have been made to homologize the arms and siphon of the cephalopods with the structures of the gastropods, but the identifications have not been entirely satisfactory. Professor Loven, as early as 1848, regarded the cephalopod arms as a persistent velum. Professor Huxley considered that they represented the gastropod foot, and the siphon was regarded as answering to the epipodial folds of the embryonic gastropod. Dr. Grenacher, however, showed that the foot of the gastropod is an unpaired structure, and therefore could not be homologous with the arms, which develop in pairs, and, like Loven, he considered that the arms represent a modified velum; the foot was deemed to be entirely wanting, while the siphon was regarded as the representative of the epipodium. Dr. Von Ihering contended that the arms are tentacular appendages to the body, and that they have no equivalent in the gastropods. The innervation of the siphon from the pedal ganglion led him to identify the siphon as the foot, and he urged that the valve of the siphon is a true foot or protopodium, and the two lateral folds pteropodia.

In 1879 Mr. J. I. Blake entered upon a comparison of the cephalopod and gastropod structures with reference to their relation to the nervous ganglia and the flexure of the intestine.* Premising that the ciliated bands constituting the velum had been shown to be traceable "from one class to another—sometimes in the larva only, and sometimes as an adult organ"—he concludes as follows: "In the primitive condition they formed a circle around the œsophagus, and as often as not are thrown out into long processes; with a change in the direction of the intestine their uniformity is broken and part dies away, while the other part is left, forming a circle surrounding, not the œsophagus, but a portion of the body on one side of it, the foot being on the other. Since, then, in the gastropoda the intestine turns to the cerebral side, we have the "velum" formed on that side; whereas in the cephalopoda, the flexure being on the opposite side, we have what we may call the *anti-velum* on the pedal side. Thus the arms are homologous to the opposite portion of the architroch to that which forms a velum, and merely afford another instance in which these primitive formations are retained as functional organs. Moreover, from within the circle of the embryonic velum rise up in some gastropods two long retractile tentacles in like manner from within the later-formed circle of the anti-velum rise up the two retractile tentacles of the decapods." The funnel is conceded to be homologous with the epipodium, and the valve in the funnel it is suggested "may represent" the foot, although this "must be doubtful."

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* Blake (J. F.). On the Homologies of the Cephalopoda. *Ann. Mag. Nat. Hist.* (5,) vol. iv, pp. 303–312.

Dr. Brooks has also treated of the same questions, and studied the development of the common squid (*Loligo Pealii*).* He recalls that the molluscan foot is an unpaired structure on the ventral surface of the body between the mouth and the anus; that in the embryo a large sinus space separates the integument of the foot from the endoderm and its derivatives; and that this space contains blood corpuscles; that the embryonic foot, in fact, is a circulatory organ. The yolk sack of the cephalopod is separated from the yolk by a corresponding sinus space, and as the integument is rhythmically the fluid which fills this space is kept in constant motion. Physiologically then, as well as in its position, the yolk sack of the squid resembles the foot of the gastropod, and consequently it is contended that we find in it the homologue of the foot. He concludes that as a locomotor organ the foot of the cephalopod has been suppressed by the great development of a food-yolk at the point where it should have been found." As to the siphon, this originates as two pairs of folds of the integument of the lateral walls of the body, and if we regard these four folds as homologous with the epipodial folds of a gastropod, the arms must be regarded as independently acquired structures. It is finally inferred that neither the exact equivalent of the arms nor of the siphon is found in the gastropods, but that these parts of the cephalopods have originated from a very generalized condition and become developed as specialized organs peculiar to the class; conversely, the foot of the gastropods is represented by no specialized structure in the cephalopods.

COMPARATIVE STRUCTURES OF THE TETRABRANCHIATE AND DIBRANCHIATE CEPHALOPODS.

As a part of his studies on the "homologies of the cephalopoda," Mr. Blake has examined into the structures which seem to correspond in the nautiloids and cuttle-fishes. The tetrabranchiates are undeniably a more primitive and generalized type than the dibranchiates, and in their adult condition exhibit characteristics which are transitory in the other. Thus (1) in the nautilus the funnel is divided, and so it is in the embryo cuttle-fish, but in the old it is a single tube; (2) in nautilus the eye is a simple cavity opening externally by a minute aperture, as is the case in the embryo cuttle; (3) in nautilus the auditory organs are close beneath the eyes, and so they are in the embryonic cuttle, but in the mature dibranchiates they have approximated on the ventral side; (4) in nautilus the tentacular and labial processes are more or less flattened and lie one within the other, and in analogous manner in the dibranchiates the arms rise as broad flat processes, one pair within the others. Mr. Blake contends (with Valenciennes) that the processes (six or eight) from which the tentacles originate in nautilus are homologous with the arms of the cuttle-fishes, and that the tentacles are homologous with the suckers. The aptychus-bearing "hood" of the nautilus may be homologous either with the anterior port of arms of the dibranchiates (the argonaut thereby secretes its shell) or with the "neck-plates" just behind the eyes and in front of the "bone" of *Sepia*, or the generalized basis of both; but this the embryology of nautilus must determine. The shell of nautilus it is thought may be represented in the dibranchiates by the shell of *Spirula*, the phragmacone of a Belemnite, and the mucro of a Sepia-bone. The ink-bag which is developed late in the embryological history of the cuttle-fishes does not exist at all in nautilus.

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* Brooks (W. K.). Homology of the Cephalopod Siphon and Arms. *Am. Jour. Sci.* (3), vol. xx, pp. 288–291; also, The Development of the Squid Loligo Pealii (Lesereur) *Anniv. Mem. Boston Soc. Nat. Hist.*

THE CEPHALOPODS OF EASTERN NORTH AMERICA.*

In the earlier works upon the mollusks of the eastern coast of North America only three or four species were recorded, and until within the last few years that coast was supposed to have few inhabitants representing that class. Since the institution of the labors of the Fish Commission, however, a number of new forms have been made known, and some of them represent new genera. Among the most noteworthy are species of gigantic cuttle-fish, of which quite a large number of specimens have now been discovered in various places on the Great Banks, and around or near the island of Newfoundland. The following are all the species that have been made known as inhabitants of the northeastern coast of the United States to the end of 1880.

DECAPODS.

Architeuthis princeps V.
Harveyi V.
Sthenoteuthis megaptera V.
Ommastrephis illicebrosa (Les.) V.
Taonius pavo (Les.) Steenstrup.
hyperboreus Steenstrup.
Histioteuthis Collinsii V.
Calliteuthis reversa V.
Rossia Hyatti V.
sublævis V.
Sepiola leucoptera V.
Logilo Pealei (Les.) V.
pallida V.
Parasira catenulata (Fer.) Steenstrup.
Heteroteuthis tenera V.

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*Verrill (A. E.). Synopsis of the Cephalopoda of the northeastern coast of America; brief Contributions to Zoology from the Museum of Yale College. No. XLVI. With plates XII to XVI. *Am. Journ. Science,* (3), vol. xix, pp. 284–295. Also, notice of the remarkable Marine Fauna occupying the outer banks of the southern coast of New England. *Am Journ. Science,* (3,) vol. xx, pp. 390–403.

OCTOPODS.

Octopus Bairdii V.	*Octopus lentus* V.
piscatorum V.	*Stauroteuthis syrtensis* V.
obesus V.	*Alloposus mollis* V.

VERTEBRATES.

NOMENCLATURE OF LIMB SEGMENTS.

In connection with an article on the Ichthyosaurian Sauranodon (subsequently renamed Baptanodon),* Professor Marsh has proposed a new nomenclature for "the corresponding segments alike of the anterior and posterior limbs of the air breathing vertibrates." Recalling that the terms "phalanges" and "metapodials" had already been applied and obtained general currency for the distal segments, he proposed to complete the nomenclature as follows:

	Anterior.	Posterior.
Propopodial bones	Humerus.	Femur.
Epipodial bones	Radius and ulna.	Tibia and fibula.
Mesopodial bones	Carpals.	Tarsals.
Metapodial bones	Metacarpals.	Metatarsals.
Phalangial bones	Finger bones.	Toe bones.

THE SEMICIRCULAR CANALS OF VERTEBRATES.

Dr. Francis Dercum has investigated the morphology of the semicircular canals in the vertebrates.† He recalls the fact that the structure of the mucous canals and of the semicircular canals is very similar, as Leydig, in 1850, had already observed. Deeming this analogy complete he asks, "Would it now be too hazardous to suggest that the two organs which are so closely related in structure and which present such significant facts as regards nerve supply and embryological development, are related genetically? Such specialization would not be inconsistent. Let us see how it may have been brought about. In an organism provided with a general apparatus for the perception of vibrations, evidently the first thing that would take place would be the specialization of certain portions for certain classes of vibrations. This is what may have been the case with the lateral canals and the ear, each being a specialization in its own peculiar direction. The fact that the involution of the side organs in Teleosts does not take place until the organism is already far advanced towards the completion of its development, and the fact that the mucous canal in the embryo of Elasmobranchs does not appear until the epiblast has been differentiated into its two layers, both imply that the side organs had for ages existed as mere "nerve hills," or nerve epithelium, projecting into the water, and this renders our idea not only possible but probable. In the course of evolution of the ear, the first differentiation of structure that occurred may have been as follows: Certain of these areas of nerve epithelium or sensory maculæ may, for functional specialization have become inclosed in canals. Now, for still greater specialization, the whole area containing the canals, with perhaps one or two maculæ not yet inclosed, may have undergone a general process of involution, and thus given rise to the vestibule and semi-circular canals."

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* Marsh (O. C.). The limbs of Sauranodon, with notice of a new species. *Am. Journ. Sc. and Arts*, (3), vol. xix, pp. 169–171, Feb., 1880.

† Dercum (Francis). On the Morphology of the Semicircular Canal. *Am. Nat.*, vol. xiii, pp. 366–374, June, 1879.

FISHES, ETC.

NOTEWORTHY WORKS, ETC.

The classes of Leptocardians, Marsipobranchiates, Selachians, and Fishes are still so generally considered together under the old designation of Ichthyology that it is convenient in practice for the present at least to recognize this grouping. The number of men deserving of scientific consideration who would now refuse the term of classes to at least three of those groups, however, is very small.

Among the general works on "Ichthyology," thus understood, that have been published during the past year or two, are "An Introduction to the Study of Fishes," by Dr. A. Günther, and parts relative to Ichthyology of the general works on natural history of Brehm's "Allgemeine Kunde des Thierreiches; and Cassell's Natural History (by H. G. Seeley). The influence of Dr. Günther is exhibited not only in his own work, but in the others noticed, and it is with regret that we have to add that influence has been for evil and to propagate and continue indefinitely some of the most unsound ideas and systematic essays that have emanated from any worker in zoology.

The geographical distribution of fishes in general has been treated of by L. Tillier. The species collected by the Challenger expedition have in part (the shore fishes) been enumerated, and the new ones described and illustrated, by A. Günther; Arctic species have been reported on by R. Collet, C. Lütken, and T. Bean; North American species have been described by D. S. Jordan, C. H. Gilbert, G. B. Goode, E. D. Cope, W. N. Lockington, &c.; those of South America by F. Steindachner; Australian species by Castelnau, H. Jouan, C. B. Klunzinger, &c.; African species by C. Dambeck, &c.

The transformations which fishes undergo after exclusion from the egg have been studied by C. Lütken and C. Emery.

The temperature of the blood in a considerable number of species has been ascertained by J. R. Kidder. His observations are noteworthy on account of the modifications which they necessitate in the statements respecting these animals current in the books.

The anatomy of fishes has received attention from many investigators, among whom are Olga Metschnikoff, M. von Davidoff, and G. Swirski, who have treated of the shoulder and pelvic girdles in whole or part; A. Cisow, who has studied the ear; G. Carlet, who has examined the scales; and M. Ussow, who has sought to explain the function of the "eye-spots" on the sides of scopelids and other types; Ad. von La Valette St. George, who has elucidated the adipose fin, and J. E. V. Boas, who has dissected the heart and contiguous parts in *Butirinus* and related fishes.

Certain groups have also received special attention. Omitting all reference to work on the Teleosts, *Petromyzon* has been anatomized by R. Weidersheim and J. E. V. Boas; the Selachians have been investigated by G. B. Ercolani, C. Hasse, S. M. Garman, and H. Rabl-Ruckhard; the osteology of Polyodon has been described by T. W. Bridge, and the embryology of Lepidosteus by A. Agassiz. Fossil fishes have been described by E. D. Cope, J. W. Davis, and R. H. Traquair.

ORIGIN OF SOUNDS PRODUCED BY FISHES.*

Many fishes are known to emit sounds of various kinds, and among those inhabiting the United States are the drum-fish and other sciænids as well as the catfishes. As to the drum-fish a recent writer (Dr. Günther, "Introduction to the Study of Fishes," p. 427) has assumed that "a tremulous motion" is communicated to vessels, and that the noise is probably "produced by the fishes beating their tails against the bottom of the vessel in order to get rid of parasites." This remarkable hypothesis renders exact observations noteworthy. The subject has received attention from several naturalists, and among them Mr. W. Sörensen, who has communicated to the French Academy of Sciences an abstract of a memoir which is to be published in full in the "Naturhistorisk Tidsskrift," of Copenhagen. Mr. Sörensen's observations were made on South American Characinids and Silurids. "The sound is produced by the action of the muscles which are inserted either directly in the swimming-bladder or upon the transverse apophyses of the third vertebra. In the Characini the elastic parts of the swimming-bladder are stretched in the direction of their length by the contraction of the muscles, and the vibration that results from this rhythmic movement is transmitted to the air contained in the cavity of the swimming-bladder. In the Siluroids the anterior portion of the swimming-bladder is drawn alternately forward and backward by the contraction and relaxation of the muscles. During these movements the air in passing across the incomplete transverse septa sets the latter in vibration, and the sound is produced. The height, or rather the depth, of the sound is in direct proportion to the rapidity of the vibrations of the springs,"—the "springs" being the transverse apophyses of the vertebræ.

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* Sörensen (W.) On the Apparatus of Sound in some South American Fishes. *Ann. Mag. Nat. Hist.*, (5,) vol. iv, pp. 99–100. (From *Comptes Rendus*, May 19, 1879.)

THE FUNCTIONS OF THE AIR-BLADDER.

The physiological relations of the swimming-bladder of fishes have been considered by Professor Marangoni, in a special communication to the French Academy of Sciences.* Some of the views enunciated were quite novel; whether they are entirely tenable remains to be seen. (1) It was contended that one of the principal results of the development of the bladder was exhibited in the migration of fishes; those destitute of that organ do not leave bottoms of little depth where there is tepid water, while those possessing it, which live in deep, cold water, periodically seek the warmer surface water to deposit their ova. (2) If living and dead fishes are placed in a vessel three-quarters full of water, and the air be then compressed, it is seen that the dead fish fall downward while the living ascend toward the surface, but if the air is rarefied the contrary is the result. They suffer from the passive influence due to hydrostatic pressure, and when brought from great depths the bladder is often ruptured. (3) The development of the bladder entails on the fish a double instability: (*a*) that of level, and (*b*) that of position. (*a*) A fish with its bladder adapted to the conditions existing at a certain depth may, through variation in pressure, be forced either upwards or downwards, and is thus in unstable equilibrium as to level. (*b*) The bladder being in the abdomen below the vertebral column, the centre of gravity is above the centre of pressure, and the animal is consequently constantly liable to inversion, and such inversion, in fact, results when inaction or death supervenes. This two-fold instability compels fishes to a constant gymnastic movement, and probably tends to conserve their strength and agility.

TEMPERATURE OF FISHES.

It has been generally asserted that the temperature of fishes was little above that of the surrounding element, except in the case of certain forms, such as representatives of the mackerel tribe—the tunny, bonito, &c.—which have been stated to have a temperature of 90° F. when the surrounding medium was 80.5°. This statement has, however, been challenged, and Dr. Kidder availed himself of the opportunities offered him while attached as surgeon to the United States Fish Commission steamer in 1879, to institute investigations upon the subject.† All the observations previously made, according to Dr. Kidder, had been confined to the intestinal canal, the thermometer being placed into the rectum or œsophagus. It is, however, by no means in either extremity of the intestinal canal that we should look for the body temperature of a fish. In point of fact the experiments show clearly enough that the rectum temperature

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*Marangoni (C.). Fonctions de la Vessie Natatoire des Poissons. *Comptes Rend. Acad. Sc., Paris*, t. xc, pp. 1293, 1294.

†Kidder (J. H.). Report of Experiments upon the Animal Heat of Fishes, &c. *Proc. U. S. Nat. Mus.*, vol. ii, pp. 306-326, 1879.

rarely exceeds that of the water in which the fish swims by so much as a degree, "so that it may be quite safely taken as an index to the latter temperature when there is no deep-sea thermometer at hand."

The experiments of Dr. Kidder were made not only in the rectum and stomach, but in various parts of the muscular tissues, the large venous trunks, the cavity of the thorax after opening the heart, the interior of the heart, and branchial artery, and the young fish in the ovary. Although Dr. Kidder admits the results to be only tentative, he considers that enough has been ascertained to show that fishes do develop animal heat by their own vital processes in the same manner, but in a less degree, as do the higher vertebrate animals, and that they will be found to manifest a temperature much above the water in which they swim. The temperature, however, varies according to the organization and the species. Thus the dog-fish (*Squalus acanthias*), in common with other sharks, "possessing a far more perfect digestive and circulatory system than the cod, shows a much greater excess of blood temperature above that of the surrounding water; and cod taken at the depth of 15 fathoms in water at 52° F., show a less excess than others taken in 25 fathoms at 41° F., but a greater excess than blue-fish (*Pomatomus saltatrix* (Linn.) Gill) taken at the surface, at 69° and 70°, which is presumably nearer the normal temperature of the last-named fish."

Ninety-seven fishes, representing 16 species, were experimented upon by Dr. Kidder, and, throwing out doubtful and imperfect observations, the following is a summary of the results:

Fish.	Temperature of surrounding water.	Temperature of rectum above water.	Temperature of circulation above water.	Remarks.
	Degrees.	*Degrees.*	*Degrees.*	
Cod	39–42	0.98	4.63	
Haddock		1.3	5.3	
Pollock	42	2.4	4.5	
Hake	42	2.4	9.8	Spawning.
Bluefish	73.2	0.25	*1.55	
Do	70.5	0.5	†1.7	
"Tinker" mackerel	65	4.1	5.25	"Thorax."
"Tinker," *S. Dekayi*	60		2.3	Do.
Sculpin	60	0.8	3.2	Do.
Sea-raven	70.6		4.4	Stomach.
Eelpout		3	6	
Flounder	42		3	
Dogfish	42	4.4	12	
Dogfish, young in ovary	42		20.6	

* Below. † Above.

THE OVARIES OF TELEOST FISHES.

Dr. J. Brock has investigated the anatomy and histology of the organs of reproduction in the male as well as female of teleost fishes.* The female organs were found to present a number of varieties in the distribution of the eggs upon the surface of the lamellæ. As these differences will prove of interest to the systematist and pisciculturist, the analytical table classifying them is here reproduced.

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*Brock (J.). Beiträge zur Anatomie und Histologie der Geschlechtsorgane der Knockenfische.

A. Ovary without duct.
1. Ovary consisting of a simple lamina (*Anguilla*).
2. Ovary consisting of numerous laminæ (*Salmonidæ*).
B. Ovary with duct.
1. Ovigerous surface confined to a narrow strip of the wall of the ovary or forming a duplicature of the wall, with which it is in connection by narrow stripes (*Scorpæna*, &c).
2. Ovigerous surface occupying the greater part of the ovarian wall.
a. Ova originate in irregular processes of the wall (*Lopohbranchii*, &c.).
b. Ova originate in definite lamellæ or duplicatures of the ovarian wall.
1. Lamellæ parallel to long axis of ovary.
a. Whole wall of ovary beset with lamellæ: canal central (*Sargus*, *Scomber*, &c.).
b. Part of wall of ovary devoid of lamellæ; canal lateral (not yet observed).
2. Lamellæ parallel to transverse axis of ovary.
a. Ovarian canal central (*Perca*, *Clupea*, &c.).
b. Ovarian canal lateral (*Cyprinoids*).

THE FLIGHT OF FLYING-FISHES.

The characteristics of the flight of flying-fishes have been much discussed and have given rise to a considerable controversial literature. In 1878, Prof. Carl Möbius re-examined the question from an anatomical and physiological as well as an observational basis, and gave his views in quite an elaborate memoir.[*] Both the Exocœtines and Dactylopterines were considered. As a result of his studies Professor Möbius came to the conclusion that the pectoral fins are not at all actively employed during flight; that the fishes "do not raise themselves, but are passively raised by the ascending currents of air, which are caught in the grooves on the under surface of their pectoral fins." It is admitted, however, that either an *exocœtus* or *dactylopterus* may "make powerful and plainly recognizable movements with its tail and pectorals during its ascent (out of water), and even occasionally in the middle of its course, if prompted thereto by a strong wetting of the body by the waves." These opinions have been challenged lately, and have provoked several communications.

Mr. C. O. Whitman[†] made special observations in the flight of *Exocœti* during a voyage from San Francisco to Yokohama, and maintains (1) that he saw them out of water "when the air was almost motionless" and that, in fact, "they were not much, if at all less numerous on such occasions than when there was a moderate wind"; (2) that the flapping movement is quite regular and very rapid; and (3) that this movement "*may be continued*" for the whole or a part of the flight, but *is generally discontinued* after the first few rods, and the course completed by a pure skimming or sailing movement." It is further claimed that "the course of the flight is generally in a straight or curved line," but is sometimes abruptly changed, "apparently by the aid of the tail," or rather the lower lobe of the caudal fin. The average flight, it is thought, "does not perhaps exceed fifteen seconds, nor extend above four or five hundred feet"; the longest observed "lasted not less than forty seconds, and its extent was undoubtedly over eight hundred feet, and may have exceeded twelve hundred feet."

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[*] Möbius (Carl). Die Bewegungen der fliegenden Fische durch die luft. *Zeitschrift für wissenschaftliche Zoologie*, vol. xxx; Supplement, p. 343.

[†] Whitman (C. O.). Do Flying Fish fly? *Am. Nat.*, vol. xiv, pp. 641–654.

Prof. D. S. Jordan also carefully examined the flight of an *Exocœtus* (*E. californicus*) in the waters of Southern California.* He observed it best "in early morning when both air and water were free from motion." "On rising from the water the movements of the tail are continued for some seconds until the whole body is out of water. While the tail is in motion the pectorals are in a state of very rapid vibration, and the ventrals are folded. When the action of the tail ceases, the pectorals and ventrals are spread, and, as far as we can see, *held at rest.* When the fish begins to fall, the tail touches the water and the motion of the pectorals recommences, and it is enabled to resume its flight, which it finally finishes by falling in the water with a splash." The flight was thought to sometimes extend to "nearly a quarter of a mile."

AFFINITIES OF PLEURACANTHUS.†

In the Carboniferous and Permian deposits have been found the remains of fishes described under the name of Pleuracanthus, whose affinities have been involved in considerable doubt. They have been mostly referred to the Selachians, although suggestions have been made that they may belong rather to the Teleosts. The question has lately been reopened by Mr. James W. Davis, and he has come to the conclusion that they claim a nearer relationship to the Teleosts than to the Elasmobranchs, although there is equal reason to believe that they possess many characteristics in common with the Sharks and Rays, and he is therefore led to place the genus in an intermediate position between the two. The affinities he thinks are decidedly on the side of the Siluroids, and it is reasonable, he thinks, to consider them as forerunners of that great group of fishes.

"It remains," he says, "to be seen what were the successive steps in

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*Jordan (D. S.). Do Flying Fish fly? *Am. Nat.*, vol. xiv, pp. 804, 805.

†Davis (J. W.). On the Teleostean Affinities of the genus Pleuracanthus. *Ann. Mag. Nat. Hist.*, (5,) vol. v, pp. 349–357.

development which have resulted in the completely ossified and highly organized Siluroids now existing."

We give these results of Mr. Davis' investigation on account of the importance of the question involved, but it seems best to add that there can be no close relationship between the Teleosts and the Selachians, and that the question as to the relationship of the palæozoic fishes can only be ascertained after the examination of specimens in a far more satisfactory condition than any that have yet been found.

THE PLATYSOMIDS AND PALÆONISCIDS.

Two of the most frequently occurring groups of fishes occurring in the paleozoic formation are the Palæoniscidæ and the Platysomidæ. The affinities of these types have been but little understood heretofore, and Dr. R. H. Traquair has therefore been led to a re-examination of the subject.* He has reached the following conclusions:

"1. That the Platysomidæ are specialized forms, which have, if the doctrine of descent be true, been derived from the Palæoniscidæ. Their structure presents us simply with a modification of the Palæoniscoid type; and wherever the Palæoniscidæ are placed in the system, thither the Platysomidæ must follow.

"2. The resemblances between the Platysomidæ and the Dapediidæ and Pycnodontidæ are mere resemblances of analogy and not of real affinity. The Dapediidæ are related not to the Palæoniscidæ or Platysomidæ, but to the other semiheterocercal Ganoids of the Jurassic era (*Lepidotus*, &c.); and the Pycnodonts are higly specialized forms, whose general affinities point in the same direction."

Professor Traquair concludes that the Palæoniscidæ and Platysomidæ belong to the "Acipenseroid sub-order of Ganoids."

The characters ascertained to distinguish the Platysomidæ and Palæoniscidæ scarcely appear to warrant the conclusions of Professor Traquair. Professor Cope, indeed, has been led by the consideration of Professor Traquair's studies to a very different result, and one approximating, apparently, more to nature. Cope† has proposed to differentiate the forms in question as representatives of "a distinct group of the same rank as those [he has] called orders," and given to it the name *Lysopteri*. They are defined as "actinopterous fishes, with the median fin-rays not joined to the interhæmal and interneural bones, and not coinciding with them in number; and without suboperculum."

ON THE SEXES OF THE EELS.‡

As is generally known, the subject of the reproduction of the eels was for a long time involved in obscurity, but many data have been accumulated within the last few years, and now we have the elements for a pretty satisfactory determination of the sexes. The ova and milt have been found by several investigators, and the last statement is that the individuals of the two sexes may be distinguished by external characteristics. In the female eel the snout is comparatively narrow, and a very considerable size is sometimes attained. In the male eel the snout is notably broader, and the length attained rarely exceeds 19 or 20 inches. The eggs of eels when mature are only about one-tenth of a millimeter in diameter, and there are several millions in the ovary of a moderate-sized individual. It is now well determined that they go to the sea, and there the sexual organs are developed, and in comparatively deep water the ova are deposited and fecundated. The young in due time ascend the rivers. The eel is thus an example of a *catadromous* fish—that is, one descending from the fresh water into the sea to breed; and thus contrasts with the salmon, shad, &c., which are anadromous—that is, ascending from the sea into fresh water to breed.

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* Traquair (Ramsay H.). The Platysomidæ. *Ann. Mag. Nat. Hist.*, (5), vol. vi, pp. 97, 98. On the Structure and Affinities of the Platysomidæ. *Trans. Roy. Soc. Edinburgh*, vol. xxix, pp. 343-391, pl. 3-6.

† Cope (E. D.). Traquair on Platysomidæ. *Am. Nat.*, vol. xiv, pp. 439, 440.

‡ Cattie (S. Th.). Ueber die Genitalien der männlichen Aale und ihre sexual Unterscheide. *Zool. Anz.*, vol. iii, pp. 275–279. (On the Genitalia of male Eels and their sexual characters. *Proc. U. S Nat. Mus.*, vol. iii, pp. 280–284.)

PLEURONECTIDS WITHOUT PECTORALS.

As is well known, some of the Soleids are more or less deficient in pectoral fins, and one genus has been named on account of the total absence of these members *Achirus*. Until lately, however, no *Pleuronectids*, in the restricted sense of the term, were known to be destitute of the fins. There nevertheless seem to be quite a number of forms belonging to the family inhabiting waters of considerable depth in which the pectorals are reduced, or may be even almost entirely wanting. Several types show gradations in that the fins in question are less developed and that of the blind side disproportionately small, but in *Monolene sessilicauda* of Goode* the pectoral fin on the blind side is "totally absent," and in a new type called *Lepidopsetta maculata* by Günther, discovered by the Challenger expedition near the Antarctic Ocean, "off Prince Edward's Island," we have the "pectoral entirely absent on the blind side, and represented by a small rudiment only on the colored."†

It may be here added that *Lepidopsetta* of Günther is entirely different from *Lepidopsetta* of Gill, and therefore should have a different name. *Mancopsetta* may be substituted and refers to the defective provision with fins.

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* Goode (G. Brown). Descriptions of seven new species of fishes from deep soundings on the southern New England coast, with diagnoses of two undescribed genera of Flounders, and a new genus related to Merlucius. *Proc. U. S. Nat. Mus.*, vol. iii., pp. 337–350 (338).

† Günther (Albert). Report on the scientific results of the voyage of H. M. S. Challenger during the years 1873–'76. Zoology, vol. i, part vi. Report on the Shore Fishes. London, 1880. (p. 18.)

A NEW CALIFORNIAN FAMILY OF FISHES.

A couple of remarkable forms were discovered, during 1880, in the Californian seas, by Messrs. Lockington, Jordan, and Gilbert. Mr. Lockington named the species discovered by him *Icosteus ænigmaticus*,* while that obtained by Messrs. Jordan and Gilbert has been called *Icichthys Lockingtoni*.† Both these forms inhabit tolerably deep water, and, indeed, are known as "deep-water fish" by the fish-dealers of San Francisco. The forms thus referred to differ in a number of peculiarities from each other, but essentially agree and have been associated by Messrs. Jordan and Gilbert under one family, to which the name *Icosteidæ* has been given. The chief distinctive character is the imperfection of the ossification and the consequently flexible bones, as well as limpness and flabbiness of the body and integuments. The family is considered to belong to the *Trachinoid* group, and is defined as follows:

"Body oblong, compressed. Head, moderate, unarmed; the suborbital without bony stay. Mouth terminal, little oblique; the premaxillary not protractile; the maxillary slender. Teeth minute, sharp, erect, in one series on the jaws only. No barbels. Gills 4, a slit behind the fourth. Gill-openings wide; the membranes free from the isthmus. Gill-rakers slender. Branchiostegals 7. Dorsal and anal fins long, without spines. Caudal fin with many recurrent accessory rays, on a slender peduncle. Pectoral fins rounded, with the carpal bones slightly exserted. Ventral fins thoracic, 1, 5, or 1, 4. Vent normal, without anal papilla. Pseudobranchiæ present."

Icosteus has a naked body (save some spinules along the lateral line), and the ventrals quadriradiate (I, 4). *Icichthys* has small scales, and the ventrals quinqueradiate (I, 5).

A NEW ECONOMICAL FISH.

On the banks off the American coast, in about latitude 40° N. and longitude 70° W., is found a fish in large numbers of a type previously to 1879 undescribed.‡ It has been made known by Messrs. Goode and Bean, under the name *Lopholatilus chamæleonticeps*. It belongs to the family *Latilidæ*, and its few-rayed vertical fins and other characters approximate it to the genus *Latilus*, but it is distinguished from all other representatives of the family, and, indeed, from all related fishes, by the development of a large adipose appendage, resembling the adipose fin of the *Salmonidæ*, upon the nape. The labial folds upon the sides of the mouth are also developed into fleshy prolongations, or tentacles. The species attains a large size, sometimes reaching or even exceeding the weight of fifty pounds. In life the color is brilliant; above it has a violaceous tint, while the lower parts are whitish, with some areas of yellow. There are numerous greenish-yellow spots, the largest about a third of the diameter of the eye; across the caudal fin are about eight stripes of the same color. "The soft dorsal has an upper broad band of violaceous, and a narrow basal portion of whitish." The first specimens obtained "were caught with menhaden bait in July, 1879, while trying for cod, fifty miles south by east of No Man's Land," at a depth of 75 fathoms, and on a very hard clay bottom. "Two miles inside of this bottom there is nothing but a green ooze, on which no fish will live." The *Lopholatilus* is very abundant and bites freely. Large numbers have been taken since the discovery, and it is possible that the species may become a regular object of fishery.

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* Lockington (W. N.). Description of a new genus and some new species of California Fishes (*Icosteus ænigmaticus* and *Osmerus attenuatus*). *Proc. U. S Nat. Mus.*, vol. iii, pp. 63–68.

† Jordan (David S.), and Charles R. Gilbert. Description of a new species of deep-water Fish (*Icichthys Lockingtoni*) from the coast of California. *Proc. U. S. Nat. Mus.*, vol. iii, pp. 305–308.

‡ Goode (G. Brown), and Tarlton H. Bean. Description of a new genus and species of Fish, *Lopholatilus chamæleonticeps*, from the south coast of New England. *Proc. U. S. Nat. Mus.*, vol. iii, pp. 205, 206, 1879.

THE ROCK-FISHES OF CALIFORNIA.

One of the most interesting and unexpected results of the investigations of Messrs Jordan and Gilbert* among the fishes of the Pacific coast of North America is the great development of species of the family of Scorpænids representing the genus *Sebastichthys* or closely related ones. Excluding *Sebastodes*, eleven species had been previously made known, and even then it was considered to be a remarkably well developed type, but the recent investigations of Messrs. Jordan and Gilbert have revealed the existence of not less than 25 species. These occur in different associations, and are found in several bathymetrical zones; they are mostly caught in large numbers by the Italian and Portugese fishermen, and taken to the markets of San Francisco. They exhibit almost every gradation in the extent of the armature of the head, and the transition between the typical representatives of the groups *Sebastichthys* and *Sebastosomus* are such as to indicate that they are of not more than subgeneric value. Some of the species are very formidably armed, as in the case of the *S. nigrocinctus* and *S. serriceps*, while others, as the *S. melanops* and *S. flavidus*, have the spinous ridges almost obsolete. Several species are very vividly colored. Such is especially the *S. rubri-*

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*Jordan (David S.), and Charles H. Gilbert. Description of a new species of "Rock-cod" (*Sebastichthys serriceps*), from the coast of California. *Proc. U. S. Nat. Mus.*, vol. iii, pp. 38–40.

——— Description of a new species of "Rock-fish" (*Sebastichthys carnatus*), from the coast of California. *Proc. U. S. Nat. Mus.*, vol. iii, pp. 73–75.

——— Description of two new species of Sebastichthys (*Sebastichthys entomelas* and *Sebastichthys rhodochloris*), from Monterey Bay, California. *Proc. U. S. Nat. Mus.*, vol. iii, pp. 142-146.

——— Description of seven new species of Sebastoid fishes from the coast of California. *Proc. U. S. Nat. Mus.*, vol. iii, pp. 287–298.

——— Description of a new Scorpænoid fish (*Sebastichthys maliger*), from the coast of California. *Proc. U. S. Nat. Mus.*, vol. iii, pp. 322–324.

——— Description of a new Scorpænoid fish (*Sebastichthys proriger*), from Monterey Bay, California. *Proc. U. S. Nat. Mus.*, vol. iii, pp. 327–329.

vinctus, which is known to the fishermen as the Spanish Flag, and is, according to Jordan and Gilbert, "the most brilliantly colored large fish on the Pacific coast." Of the species of the genus as understood by our authors, 23 have been already detected in or near the bay of San Francisco, 25 in Monterey Bay, 14 at Santa Barbara, 5 at San Diego, and 9 occur as far north as Puget Sound.

A DEEP-SEA ROCK-FISH.

As has been indicated with regard to the Californian Scorpænids, the successive bathymetrical zones are inhabited by different species, and as we descend downwards we find one set of species gradually disappear, to be succeeded in the lower zone by another combination. It has been conjectured that in still deeper water we may find yet other forms. What may be expected is suggested by a species secured by the Challenger Expedition in the "Inland Sea of Japan," off Inosima, at a depth of "345 fathoms." It has been illustrated by Dr. Günther (Report on the Shore Fishes, p. 65, pl. 27),* under the name of *Sebastes macrochir*, without any consideration of its relations. It is, nevertheless, noteworthy for several peculiarities. The typical species of *Sebastes* have 15 (14+1) dorsal spines and about 30 (*e. g.*, 12+19) vertebræ, while the species of *Sebastichthys* and allied forms have 12 or 13 (12+1) dorsal spines, and 24 (14+10) vertebræ. The "*Sebastes macrochir*" has, like the typical species of *Sebastes*, 15 (14+1) dorsal spines, but the vertebræ are unknown, although they are probably developed in increased numbers. (The soft portion of the dorsal is said by Dr. Günther to have six rays, but nine are figured.) The principal characteristics of the species, however, are the peculiar structure of the pectorals and ventrals, and the position of the latter. The pectorals have a wide base, and are produced backwards near the upper margin (and not medially), while the (five) lower rays are thickened and extend much beyond the rays next above in a linguiform lobe; the ventrals are situated directly under (and not behind) the axils of the pectorals, and the outer rays are produced thick and unbranched. These characteristics are the more noteworthy, inasmuch as many deep-sea fishes have the lower pectoral and ventral rays differentiated and modified as "feelers." The "*Sebastes macrochir*" is evidently not a true "*Sebastes*," and, on account of the form of the pectorals and position of the ventrals just indicated, should be distinguished generically. It may be called *Sebastolobus macrochir*.

REPTILES, ETC.

FEATURES OF PROGRESS.

Like ichthyology, herpetology is a common denominator for very different classes—the amphibians and reptiles—which receive attention as a whole from the same specialists. As in the case of ichthyology, only a few of the numerous contributions to the branch made during the past two years can be referred to.

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* Günther (Albert). Report on the Scientific Results of the Voyage of H. M. S. Challenger. Zoology, vol. i, part vi. Report on the Shore Fishes. London, 1880. 4to., 82 pp., 32 pl.

The systematic arrangement has been exhibited in the popular works on natural history published under the names of Bronn (by C. K. Hoffman), Brehm, and Cassell (by H. G. Seeley).

The skull has been examined in various stages of development by P. Stohr (for Urodela), and W. K. Parker (for typical lizards, chameleons, and turtles), while R. Wiedersheim has monographed the entire skeleton of a salamander—*Pleurodeles*. The heart and its functions have been studied by M. Löurt, B. Luchsinger, and G. Siebert; and the Embryology by C. von Bambeke and F. M. Balfour (for the lizards).

New species have been described by many, E. D. Cope being the most prominent among American naturalists, while several marine chelonians have received new names from S. W. Garman.

Various faunas have likewise received attention. O. Boettger and E. Boser have attended to the Portuguese Amphibians and A. Tourneville to the French ones, and discovered what they have considered to be "new species" in those old, long-known countries.

The Cœcilians have been investigated by both W. Peters and R. Wiedersheim; the poisonous serpents of Europe by E. de Betta.

The extinct species have received the attention of E. D. Cope and O. C. Marsh in the United States, and in England of J. W. Hulke, R. Owen, H. G. Seeley, and W. H. Twelvetrees.

ICHTHYOSAURUS VIVIPAROUS.

Within the body cavity of various Ichthyosauri small individuals of the form have been several times found, and it has been generally supposed that they had been devoured by the large ones. Professor Seeley has, however, looked into the question, and has come to the conclusion that *Ichthyosaurus* was really viviparous. The position of the small skeletons within the body is such as to make the viviparity of the animal much more probable than the inclusion by swallowing. There is at any rate no inherent improbability whatever in the viviparity of the type. Indeed the question whether a reptile is viviparous or oviparous is of comparatively little moment, as it simply depends upon a slight degree of retardation in the retention of the ova, or the inclusion for a slightly longer time within the body of the parent. There is no significance such as exists between the viviparity of mammals and the oviparity of birds. (*Academy;* also, *Am. Nat.*, vol. xiv, p. 60, January, 1880.)

THE LIMBS OF MOSASAUROIDS.*

Among the most interesting of the reptiles of the Cretaceous epoch are the Mosasauroids, first introduced to science through a gigantic "Saurian" whose remains were found in the valley of the Meuse in Germany (whence the name). Recent discoveries in America have greatly enlightened us as to the characteristics and peculiarities of structure of the type. The group was much better developed in America than in Europe, and the skeleton is now tolerably well known. It has been asserted that the form was destitute of limbs, or at least of a pelvis and sternum, and that in this as well as in other respects it approached the Ophidians rather than the true Saurians. Professor Marsh has recently discovered remains which prove conclusively that they had a well-developed scapular arch and a sternum of goodly proportions, and that there was an equally well developed pelvis, with pubic, iliac, and ischiac bones, all distinct and of good size. Another bone, not previously found, is the "transverse bone" of Cuvier, or "ectopterygoid" of Owen. This has likewise been detected in several genera, and is an L-shaped bone, suturally united by one ramus with the corresponding processes of the "pterygoid" and joining at the other the posterior end of the maxillary. Professor Marsh has further identified (1) as pterygoid bones, those also called pterygoid by Cuvier and which have well developed teeth, while he considers (2) as palatines, small edentulous bones in front and outside the pterygoids, and interposed between them and the slender vomers. Hence Professor Marsh concludes that the new characters thus presented are all Lacertilian rather that Ophidian, but inasmuch as the Mosasauroids are distinguished by various important characters, he proposes to segregate them, as a suborder under the name "Mosasauria." As a previous name had been given to the group, however—Pythonomorpha—that name should be retained, whatever may be the valuation that attaches to the distinctive characters.

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* Marsh (O. C.). New Characters of Mosasauroid Reptiles. *Am. Jour. Science,* (3,) vol. xiv, pp. 83–87, pl. 1.

Owen (R.). On the occurrence of rare extinct Vertebrates found fragmentarily in England. No. 3. *Ann. and Mag. Nat. Hist.*, (5,) vol. v, pp. 177–181, pl. 8.

BIRDS.

ILLUSTRATED VOLUMES, ETC.

The usual activity has been manifested by ornithologists. The tendency to give an exaggerated value to trivial characters still lingers. One author,* for example, recognizes two *subclasses* and 26 *orders* in this most homogeneous of types, and for the little morphologically diversified Passeres not less than 53 *families* are provided! Numerous memoirs on the birds of special regions, on various groups of the class, on the anatomy of certain types, and on the system in general have been published in the organs of sundry societies and in other periodicals and reviews. A number of special volumes have also been issued, and among such the following serial publications are the most noteworthy.

Of faunistic works are: F. DuC. Godman and O. Salvin's "Biologia Centrali-Americana" (parts 1 to 7); J. Gould's "Birds of Asia" (parts

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* Sclater (P. L). Remarks on the present state of the Systema Avium. *Ibis*, (4,) vol. iv, pp. 340–350, 399–410.

-32); J. **GOULD'S** "Birds of New Guinea and adjacent Papuan Islands," &c. (parts 9-11); V. **LEGGE'S** "History of the Birds of Ceylon" (part 3); T. **SALVADORI'S**, "Prodromus Ornithologiæ Papuasiæ et Moluccarum (parts 6-9).

Of families are: D. G. **ELLIOT'S** "Monograph of the Bucerotidæ, or family of Hornbills (parts 7-8); J. **GOULD'S** "Supplement to the Trochilidæ, or Humming Birds" (part 1); P. L. **SCLATER'S** "Monograph of the Jacamars and Puff-Birds, or families Galbulidæ and Bucconidæ" (part 4); G. E. **SHELLEY'S** "Monograph of the Cinnyridæ, or family of Sun-Birds" (parts 7-).

And of continuations of general works are: H. **SCHLEGEL'S** "Muséum d'Histoire Naturelle des Pays-Bas" (tome 8, including Tinamids and Megapodids); R. **BOWDLER SHARPE'S** "Catalogue of the Birds of the British Museum" (vol. 4, containing the "Campophagidæ and Muscicapidæ").

THE ODONTORNITHES, OR TOOTHED BIRDS.*

Perhaps the most trenchant ideas associated in our minds with birds relate to the development of the feathers, the insertion of the tail in a fan-like manner, and a bill destitute of true teeth, although frequently provided with serrations or special odontoid enlargements of the cutting edges. In the Cretaceous period, however, there must have existed many forms possessing characters in which they resembled reptiles rather than living birds. One of those types, as is now generally known, was distinguished by the development of numerous caudal vertebræ of elongated form, extended backwards, and provided with feathers on the lateral edges, thus contrasting remarkably with the abbreviated concentrated coccyx and radiate feathers of the living forms. This ancient type (*Archæopteryx*) also differed in so many respects from the typical birds, and on the other hand approached the reptiles, that even recently the opinion has been expressed by an eminent naturalist, Carl Vogt, that it was really a reptile rather than a bird. This form appears also to have been provided with well-developed teeth, although the exact characters of those teeth remain yet to be elucidated. In America there existed at nearly the same period forms which, in most respects, approached the typical birds more than did the *Archæopteryx*, but which, nevertheless, were distinguished by well marked characters. There were two of these types.

In one form the vertebræ were bi-concave, (thus resembling those of fishes and the Gecko lizards,) and the teeth were well developed and implanted in regular disconnected sockets and partly shed and replaced by others of later growth. The species possessing these characters, so far as they have come to light, had also large wing bones, and the meta-

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*Marsh, (O. C.). Odontornithes: A Monograph on the Extinct Toothed Birds of North America, with thirty-four plates and forty wood-cuts. Washington, Government Printing Office, 1880. 4to, pp. i-xv, 201. Also, A Monograph on the Odontornithes, or Toothed Birds of North America. By Prof. Marsh. *Am. Jour. Science* (3) vol. xxi, pp. 255-276. April, 1881.

carpals were anchylosed. These have been distinguished as typical of an order which has been called by Professor Marsh "*Odontotormæ.*"

Another form had vertebræ like those of living birds—*i. e.* saddle-shaped—and the teeth, although well developed, were implanted in a groove and not in distinct sockets. The wing bones in the typical forms were small, and no metacarpals have been found. These have been regarded as also constituting a distinct order, to which Professor Marsh has given the name "*Odontolcæ.*"

ARCHÆOPTERYX.

It will be remembered that the scientific world was somewhat startled by the discovery in 1861 of the body of an animal in lithographic stone at Solenhofen in Bavaria, which appeared to be intermediate between the reptiles and the birds, and which exhibited a combination of characteristics found in neither of those classes. While by some it was believed to be a reptile, by Professor Owen, who gave an elaborate monograph of it, it was referred to the class of birds, and since then has generally been conceded to belong thereto. Lately a second specimen has been found by Mr. Haberlein, a son of the discoverer of the first, and has been the subject of a renewed examination by Prof. Carl Vogt.* Some additional characteristics have been revealed by the specimen; the head is preserved in a much better condition than in the first specimen, and the jaws can be examined. The latter in the upper mandible has two small conical pointed teeth. The following summary gives the conclusion of Professor Vogt:

"The head, the neck, the thorax with the ribs, the tail, the thoracic girdle, and the whole anterior member are clearly constructed as in reptiles; the pelvis has probably more relation to that of reptiles than that of birds; the posterior limb, on the contrary, is that of a bird. In all respects the reptilian homologies predominate in the skeleton. There remain the feathers. Here there is no doubt; they are birds' feathers with a central rachis and with perfectly formed balbules. The horny substance of the feathers has disappeared, but the model in the fine paste of the lithographic stone is so complete that we may study the smallest details with the lens. The new slab shows all the feathers in their place. The remiges are attached to their cubital margin of the arm and hand; they are covered for about half their length with a fine filiform down; none of the remiges projects beyond the others; the wing is rounded in its outline like that of a fowl. It is possible that there was at the base of the neck a collar similar to that of the condor; at least it has been thought that indications of such a thing could be seen. The tibia was covered with feathers throughout its whole length. The *Archæopteryx* therefore had breeches like our falcons, with which, according to Professor Owen, it has the most resemblance in the leg. Each caudal vertebra bore a pair of lateral rectrices; all the rest of the body, head, neck, and trunk, were evidently destitute of feathers and naked; we should certainly otherwise have found traces of feathers upon a slab which has preserved even the smallest traces of a fine down. Hence the restorations of the animal hitherto attempted are quite erroneous."

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* Vogt (Carl). On Archæopteryx macroura. *Ann. Mag. Nat. Hist.*, (5,) vol. v, pp. 185–188. (Translated from *Bibliothèque Universelle.* 1879, pp. 702–703.

According to Professor Vogt the *Archæopteryx* is neither a reptile nor a bird; although bird-like in its integument and hinder limbs, it is reptilian in all the rest of its organization.

The Archæopteryx has been derived, Professor Vogt thinks, from "the lizard-like terrestrial reptiles, having feet with five hooked, free digits, showing no modification in their skeleton, but having the skin furnished at different points with elongated warts, downy plumes, and rudimentary feathers, not yet fitted for flight, but susceptible of further development in the course of generations."

THE EXTINCT PARROT OF BOURBON.

It has been for some time recognized that the large parrots which existed in the islands of Mauritius and Rodriguez, when those lands were first visited by Europeans, represented peculiar generic types—that of Mauritius the genus *Lophopsittacus*, and the one of Rodriguez the genus *Necropsittacus*. The large parrot of the isle of Bourbon or Réunion has, however, been generally associated with the *Coracopsis nigra* of Madagascar. It was introduced into systematic ornithology in 1760 by Brisson, and a specimen (presumably described by him) is still preserved in the museum of the "Jardin des Plantes," although the bird has long been extinct. Mr. W. A. Forbes has re-examined the specimen and come to the conclusion* that the species was not a natural associate of *Coracopsis*, but the type of a peculiar genus for which he revives Lesson's name *Mascarinus*, and gives to it the new name *Mascarinus Duboisi*. (It may be recalled here that G. R. Gray restricted the name *Coracopsis* as a subgeneric term to the Bourbon parrot and revived the name *Vaza* (of Lesson) for the *C. nigra.*) It is, he thinks, "allied rather to such palæornithine genera as *Palæornis* and *Tanygnathus*, than to *Psittacus*, *Coracopsis*, or allied forms." The extreme specialization of the several types of parrots thus restricted to the islands indicated is one of the most interesting facts in ornithology, and points to a long isolation of the areas to which they were respectively confined.

MAMMALS.

FEATURES OF PROGRESS.

The usual number of contributions have been made to the anatomy of different groups and species of mammals, and to faunal lists and works. Giebel's Treatise on Mammals, contributed to Bronn's "Klas-

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*Forbes (W. A.). On the systematic position and scientific name of "Le Perroquet mascarin" of Brisson. *The Ibis*, (3,) vol. iii, pp. 303–307.

sen und Ordnungen des Thierreichs," has been continued and a number of parts issued during the past two years. Trouessart's catalogue of all the living and extinct species has also been continued in the "Revue et Magasin de Zoologie." The most important of the many memoirs on special groups is Allen's on the Pinnipeds of North America, which contains besides a revision of those of other parts. The teeth have been examined partly as to their mechanical and partly as to their taxonomic relations, by Hensel and Ryder.

The placentæ of Edentates of the families of Dasypodidæ and Bradypodidæ have been examined by Milne Edwards and Joly,—the former by Edwards and the latter by Joly.

O ——— has made a special investigation of the muscle of the eye in the apes and monkeys. The foramina of the base of the skull have been again investigated with reference to systematic values by Cope for the Æluroid Carnivores and by Wingie for the Insectivores.

THE PROGENITORS OF MAMMALS.

The parents of mammals have been chiefly sought for in recent times among the early reptiles, and it has been supposed that they were descended from forms closely related to the Dinosaurians of the Jurassic and Cretaceous epochs. In a recent memoir on the characteristics of the pelvis in the mammals, Professor Huxley has challenged this view,* and has expressed his belief that "it appears to be useless to attempt to seek among any known Sauropsida for the kind of pelvis which analogy leads us to expect among those vertebrated animals which immediately precede the lowest known Mammalia; for, if we prolong the series of observed modifications of the pelvis in this group backwards, the 'Promammalia' antecedent to the Monotremes may be expected to have the iliac and obturator axes perpendicular to the sacral axis, and the iliopectineal axis parallel with it; something, in short, between the pelvis of the *Ornithorhynchus* and that of a land tortoise; and provided, like the former, with large epipubes intermediate in character between those of the lower mammals and those of crocodiles." As this condition is not fulfilled in the Reptiles, Professor Huxley thinks that the original mammals have descended from an entirely different stock. He asserts that in such a pelvis as the salamander, for example, "we have an adequate representation of the type from which all the different modifications which we find in the higher vertebrata may have taken their origin." He therefore deduces the conclusion that mammals have been derived from the Amphibians through "some unknown 'promammalian' group, and not from any known forms of Sauropsida." In corroboration of this view he adduces the two condyles of the occipital of the skull in which the mammals are paralleled by the Amphibians; and urges that only in the Amphibians is the articular element of the mandibular arch persistently cartilaginous, while the quadrate ossification is small, and "the squamosal extends down over it to the osseous elements of the mandible, thus affording an easy transition to the mammalian condition of these parts." Further, "the pectoral arch in the Monotremes, it is claimed, is as much like that of the Amphibians as it is that of any Sauropsidan; and the carpus and tarsus of the mammals are directly deducible from the urodele amphibian type. (It is also suggested that the calcar of the frogs is in some respects comparable with the spur of the Monotremes, though this is rather irrelevant.) Finally, it is said "in all Sauropsida it is a right aortic arch which is the main conduit of arterial blood leaving the heart, while in mammals it is a left aortic arch which performs this office." This discrepancy is thought to be "a great stumbling-block in the way of the derivation of the Mammalia from any of the Sauropsida; but if we suppose the earliest forms of both the Mammalia and the Sauropsida to have had a common amphibian origin, there is no difficulty in the supposition that from the first it was a left aortic arch in the one series and the corresponding right aortic arch in the other, which became the predominant feeder of the arterial system."

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* Huxley (T. H.). On the Characters of the Pelvis in the Mammalia and the Conclusions respecting the Origin of Mammals which may be based on them. *Proc. Royal Society*, vol. xxviii, pp. 395–405, pl. 8.

In later publications* Professor Huxley has reiterated his opinions. The ancestors of mammals or "Promammals" would be distinguished from the Sauropsida by the possession of two occipital condyles and the enlarged size and functional development of the left aortic arch, while they would "probably be no less differentiated from the Amphibia by the presence of an amnion and the absence of branchiæ at any period of life." He does not doubt that "when we have a fuller knowledge of the terrestrial vertebrata of the later Palæozoic epochs, forms belonging to this stage will be found among them." A type like the one thus supposed without the amnion and corpus callosum, and provided with functional branchiæ, would find a place among the Amphibians. In the line of descent, from the primitive vertebrate to the mammals, neither the reptiles nor birds would intervene, they, according to Huxley, representing "as it were side-tracks starting from certain points of that line" intermediate between the amphibian and mammalian stages of evolution.

MAMMALS OF THE AMERICAN JURASSIC.

Previous to 1827, we had very little definite information respecting the former existence of mammals in the Jurassic epoch of North America, although Emmons had indicated that a form of that class had left remains in certain beds in North Carolina. In the last several years, however, quite a number of species have been indicated, and based upon lower jaws or fragments thereof, found in various beds in the Western Territories. Up to the present time 13 nominal species, representing six genera, have been discovered. These have been named and indicated in the American Journal of Science, as follows:

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* Prof. Huxley on Evolution. *Nature*, vol. xxiii (1), pp. 203-204, Dec. 30, 1880; (2), pp. 227-231, Jan. 6, 1881.

xv. 1878, June (459). Dryolestes priscus.
xviii. 1879, July (61). Stylacodon gracilis. (Stylodontidæ named.)
xviii. 1879, Sept. (215). Dryolestes vorax.
(216). Tinodon bellus) (Tinodontidæ named.)
xviii. 1879, Nov. (396). Ctenacodon serratus. (Plagiaulacidæ (Gill 1871) renamed.)
(397). Dryolestes arcuatus. (Dryolestidæ named.)
(397). Tinodon robustus.
(398). Tinodon lepidus.
xx. 1880, Sept. (235). Diplocynodon victor.
(236). Stylacodon validus.
(236). Tinodon ferox.
(237). Triconodon bisulcus.
(237). Dryolestes obtusus.

In a very recent contribution to the knowledge of these types, Professor Marsh has proposed to differentiate certain of these forms into two orders, one of which he nas named *Pantotheria* and the other *Allotheria.*[*]

The *Pantotheria* are distinguished by "(1) cerebral hemispheres smooth; (2) teeth exceeding or equaling the normal number, 44; (3) premolars and molars imperfectly differentiated; (4) canine teeth with bifid or grooved fangs; (5) rami of lower jaw unanchylosed at symphysis; (6) mylohyoid groove distinct on inside of lower jaws; (7) angle of lower jaw without distinct inflection; (8) condyle of lower jaw near or below horizon of teeth; and (9) condyle vertical or round—not transverse." To the group thus defined Professor Marsh thinks that, with the exception of a very few aberrant forms, the known Mesozoic mammals may be mostly referred.

The *Allotheria* are distinguished by having "(1) teeth much below the normal number; (2) canine teeth wanting; (3) premolar and molar teeth specialized; (4) angle of lower jaw distinctly inflected; (5) mylohyoid groove wanting." The group so distinguished is proposed for the genus *Plagiaulax*, represented by a species originally described by Owen, and of which representatives have been likewise found in America, and to it are referred the new genus *Ctenacodon* of Marsh, "and possibly one or two other genera."

It will be out of place to traverse the conclusions of Professor Marsh, but those best acquainted with the mammals will agree that whatever may be the relations of the forms above differentiated, it still remains to be proved that they are entitled to ordinal distinction, for certainly the characters adduced are not generally considered to be entitled to such value by the majority of modern therologists.

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[*] Marsh (O. C.). Notice of Jurassic Mammals representing two new Orders. *Am. Journ. Science,* (3,) vol. xx, pp. 235–239, Sept. 1880. (See, also, vol. xv, p. 459; vol. xviii, pp, 60, 215, 396, 1879.)

DASYURIDS IN NEW GUINEA.

The mammalian fauna of New Guinea, until within the last few years but little known, has assumed a special interest on account of the number of types discovered related to Australian forms. Many groups that were supposed to be peculiar to Australia have been found in the great island. Among the most unexpected discoveries were those of two distinct generic representatives of the family of Tachyglossids or Echidnids. Besides these have been found true Phalangers, Dwarf and Flying Phalangers, Cuscus, Kangaroos, Bandicoots, and Phascogales. No typical carnivorous Marsupial had, however, been found, but recently a species of that group has also been discovered. The species in question belongs to the family of Dasyurids, and has been made known by Professor Alphonse Milne Edwards.* Specimens were obtained in the Arfak Mountains, at the entrance of the Bay of Gelwinck, on the north coast of New Guinea, by the collectors of M. Bruijn, of Ternate. The new species has been named *Dasyurus fuscus*. It is smaller than any of those previously made known, little exceeding in size a large rat. Its color is a very dark brown, but yellowish beneath; there are small white rounded spots, regularly disposed on the upper part of the body, and on the flanks, shoulders, and thighs. The tail is long and not bushy. The short thumb is destitute of a nail. It is thus most closely related to the *Dasyurus hallucatus* of the northern extremity of Australia.

PLAGUE OF RATS.

It is tolerably well known that in various countries—especially tropical ones—once every few years there is a raid of enormous numbers of "rats," or rat-like rodents, on the cultivated crops of the planters. A plausible hypothesis has lately been promulgated correlating such incursions with the maturation and death of plants whose progressively increasing fruit, till a certain period, furnish food for the increasing rodents; but when the crowning crop has flourished and disappeared the animals are forced to disperse in search of the food denied them in their old homes.

Mr. Orville A. Dewey has contributed to the Rio News a communication reproduced in Nature† on the rat plague observed in the Brazilian province of Parana. "This invasion, or plague as it is called, is said to occur at intervals of about thirty years, and to be simultaneous with the dying of the *taquara*, or bamboo, which everywhere abounds in the Brazilian forests." In explanation it is alleged that "the bamboo arrives at maturity, flowers, and seeds at intervals of several years, which doubtless vary with the different species. The period for the species most abundant in Parana is thirty years. The process, instead of being simultaneous, occupies about five years, a few of the canes going to seed the first year, an increased number the second, and so on progressively, till finally the remaining and larger portion of the canes seed at the same time. Each cane bears about a peck of edible seed," and the amount produced is enormous. After seeding, the cane dies. "The rats, suddenly deprived of food, commence to emigrate, invading the plantations and houses, and consuming everything that does not happen to be repugnant to the not very fastidious palate of a famishing rodent."

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* Edwards (Alphonse Milne). On a new species of Dasyurus from New Guinea. *Ann. Mag. Nat. Hist.*, (5), vol. vi, pp. 171, 172.

†Dewey (Orville A.). Plague of rats in Brazil. *Nature*, vol. xx, p. 65.

Mr. Frederick Lewis, in a subsequent notice,* correlates similar visitations of rats in Ceylon "with the flowering and death of the *Nilloo* (*Strobilanthes*), which forms the greater part of the underwood of Ceylon forests, and is said to flower and die every seven years."

Mr. Frederico Philippi, of Santiago, Chili,† records that in the south of Chili that analogous swarms of rats occur, and are also coincident with the crowning fructification and subsequent death of a bamboo—a species called Colligue—whose period is 15 to 25 years.

THE HABITAT OF LOPHIOMYS IMHAUSI.‡

One of the most remarkable of living mammals is the form described in 1867, by A. Milne Edwards, under the name *Lophiomys Imhausi.* It is, it has been well remarked, "one of the very best examples of 'defensive mimicry' known in the animal kingdom." The specimen through which the species was originally made known was accidentally bought alive by M. Imhaus, at Aden, in 1866, and thus Professor Edwards was enabled to obtain tolerably complete information respecting the organization and peculiarities of the unique mammal. It has been since asserted, however, that the specimen in question was not an Arabian autochthone, but must have been brought from the opposite continent and probably from some place in Nubia or Abyssinia. Four specimens have now been obtained and are preserved in different European museums. As indicated by Giglioli, the native country of the species is "now pretty well defined by lines drawn from Suakin to Maman and Kassala, and thence southward towards the Somali coast." The species appears to be rare in its native country, or at least it is not often seen. This may be on account of its habitat, for "it lives in deep holes in the strangely fissured rocks" of the region in which it dwells. It is a vegetable feeder, of course, and the stomach of a specimen obtained at Erkanid, on the mountains between Suakin and Singat, was found to be "distended with leaves and young shoots."

PROPORTIONS AND GESTATION OF THE INDIAN ELEPHANT.

Some exact observations have lately been published in the period of gestation and the dimensions of the Indian elephant, which are of general interest.

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* Lewis (Frederick). Plague of Rats. *Nature*, vol. xx, p. 267.

† Philippi (Frederico). A Plague of Rats. *Nature*, vol. xx, p. 530.

‡ Giglioli (Henry H.). "Lophiomys Imhausi." A. Milne Edwards. *Zoologischer Anz.*, vol. iv, p. 45.

Four of the elephants in the gardens of the Zoological Society of London were weighed and measured by A. D. Bartlett,* the superintendent of the society's gardens, and the following figures give the result:

	Height at shoulder.		Circumference of the front foot above the toes.		Weight.			
	Ft.	*In.*	*Ft.*	*In.*	*Tons.*	*Cwt.*	*Qrs.*	*Lb.*
Jung Pacha	7	0	3	8	2	3	0	23
Suffa Culli	6	10	3	8	2	2	3	11
Omar	6	2	3	2	1	7	1	5
Rustom	6	0	2	11	1	3	3	26

The period of gestation has been recorded by two gentlemen, Colonel Heysham, of the Madras Commissarial Staff,† and Mr. Arthur E. Brown, superintendent of the gardens of the Zoological Society of Philadelphia.‡ According to Colonel Heysham the period in the two cases noted was nineteen months, and, according to Mr. Brown, the exact period was 629 days (from June 20, 1878, to March 10, 1880). The new-born elephant weighed 213 pounds, and its height at the shoulder was 34½ inches and the circumference of the fore feet 17 inches. "The young was up and walking about very shortly after birth, has teeth in both jaws, and sucks with the mouth. The mamma of the mother, when distended, projects somewhat laterally, so that the trunk of the young one is thrown up, and rests, when sucking, in the angle between the shoulder and thorax."

LIFE PERIODS OF THE HIPPOPOTAMUS.§

Observations in several zoological gardens have furnished the basis for some essential data in the life of the hippopotamus. It takes about five years for growth, although it may continue to increase in stoutness afterwards, and has been known to live nearly thirty years. The sexual vigor of the male doubtless extends over at least twenty years, and perhaps somewhat more. The period of gestation in the female ranges ordinarily from 236 to 240 days, and in one instance birth ensued 227 days after intercourse with the male.

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* Sclater (P. L.). Report on the dimensions and weights of the Indian Elephants. *Proc. Zool. Soc., London,* 1879, pp. 385–388.

† Heysham. Extract from a letter addressed to the president, containing remarks upon two cases of elephants breeding in captivity. *Proc. Zool. Soc., London,* 1880, pp. 23–24.

‡ Brown (Arthur E.). Letter from, relating to the birth of an elephant in a menagerie at Philadelphia. *Proc. Zool. Soc., London,* 1880, pp. 222–223.

§ Owen (R.). On the Natural Form of Life and its chief periods in the Hippopotamus. *Ann.* and *Mag. Nat. Hist.,* (5,) vol. iv, pp. 188–190.

AN OLD AMERICAN BEAR.*

In the period shortly antecedent to that characterized by the existing fauna, there lived in California an animal of the bear family equaling in size the grizzly of our own days. The dental series was distinguished by the absence of distemas, or intervals between the canine and contiguous teeth, and therefore the species was generically differentiated from any living form. The Californian species seems, however, to have been related to a European ursid, which possessed the same character, and which has been made known as a peculiar generic type under the name *Arctotherium.* The bear of California has, therefore, been generically identified with this and described as *Arctotherium simum.* The remains described by Professor Cope were found in a cavern in the carboniferous limestone of Shasta County, California, beneath several inches of cave earth and stalagmite.

EXTINCT CAT-LIKE ANIMALS OF AMERICA.

Professor Cope has recently† subjected to renewed examination the Felids and certain forms that had been supposed to belong to that family, and has found that the characteristics found in all the existing species are wanting in some extinct types that are otherwise closely related. Such are the genera *Archælurus*, *Nimravus*, *Dinictis*, *Pogonodon*, and *Hoplophoneus* of the American Lower Miocene, and probably also the *Proœlurus*, *Ælurogale*, and *Eusmilus* of the European Eocene and Miocene. These genera, so far as they have been critically examined, contrast with living Felids in that there is (1) a distinct carotid foramen; (2) the condylar foramen does not enter the foramen lacerum posterius; (3) postglenoid and (4) postparietal foramina exist; and (5) an alisphenoid canal is developed. These characters, in the opinion of Professor Cope, are of family value, and consequently the genera so distinguished are segregated under the name *Nimravids.* In most other characters, as well as in dentition, they agree with the Felids. The several types, it is said, "form an unusually simple series, representing stages in the following modifications of parts: (1) in the reduced number of molar teeth; (2) in the enlarged size of the superior canine teeth; (3) in the diminished size of the inferior canine teeth; (4) in the conic form of the crowns of the incisors; (5) in the addition of a cutting lobe to the anterior base of the superior sectorial tooth; (6) in the obliteration of the inner tubercle of the lower sectorial and (7) in the extinction of the heel of the same; (8) in the development of an inferior flange and latero-anterior angle of the front of the ramus of the lower jaw; (9) in the development of cutting lobes on the posterior borders of the large premolar teeth." Twenty-one species of the new family are recognized, 12 of which are confined to the American Lower Miocene and 1 to the American Upper Miocene. Of the other species in Europe 3 occur in the Upper Eocene, 2 in the Lower Miocene, 1 in the Upper Miocene, and in India 1 in the later Miocene or Pliocene.

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* Cope (E. D.). The Cave Bear of California. *Am. Nat.*, vol. xiii. Dec., 1879. *Sill, Jour.*, vol. xix, p. 155.

† Cope (E. D.). On the Extinct Cats of America. *Am. Nat.*, vol. xiv, pp. 833–858, Dec., 1880.

THE REPRESENTATIVE STRATA OF EUROPE AND NORTH AMERICA AS DETERMINED FROM VERTEBRATE DATA.*

There has been only approximate parallelism of the strata of North America and Europe from their Invertebrate remains, and inasmuch as the later deposits are better characterized by the Vertebrates than by the Invertebrates, a comparison with relation to the former was much needed, and this Professor Cope has lately undertaken. He premises that "if the types of life have originated independently we will find evidence of it by studying American palæontology; if their origin has been through gradual modification, America should furnish us with many intermediate faunæ." To solve this question he thinks "the identification of the generic types of North American Vertebrata has now advanced to a point which renders such a comparison possible." This comparison is begun with the coal measures and especially with the Batrachians of that period. The Carboniferous Batrachians are "not yet sufficiently well known to enable the most exact comparison to be made, but close parallels, if not identities, of genera exist. Such are the *Oëstocephalus* and *Ceraterpeton*, of Ohio, as compared with the *Urocordylus* and *Ceraterpeton* of Great Britain." The Permian vertebrate fauna, as represented in Illinois and Texas, "exhibits close parallels, but not yet generic identity in the two continents." The Triassic fauna is much better known in Europe than in America, the marine Trias being little developed, and the vertebrate fauna of the Muschelkalk being entirely unknown in the latter country. The Keuper, however, is represented, and a characteristic type (*Belodon*) existed in both continents. The Jurassic faunæ have been thought to be but poorly represented in the New World. "We do not yet know any deposits in North America which contain the typical reptilian genera *Plesiosaurus*, *Ichthyosaurus*, *Pliosaurus*, and *Dimorphodon*, or the fishes of the *Dapediidæ;*" although recent discoveries by Professor Marsh presage much for the future. "A few more characteristic fossils of the Rocky Mountain region represent the Oölite—particularly the upper Oölite—while *Teleosaurus* and *Steneosaurus*, and their allies, are not yet known from North American beds."

The Cretaceous fauna is very well developed in North America. "The ocean of the interior of the continent deepened from the beginning of the period until the epoch of the Niobrara, and then gradually shallowed until the elevations of the bottom began to divide the waters. The closing scenes of this great epoch were enacted amid a labyrinth of lagoons

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*Cope (E. D.). The Relations of the Horizons of Extinct Vertebrata of Europe and North America. *Bul. U. S. Geol. and Geog. Survey Ter.*, vol. v, pp. 33–54.

and lakes of brackish and fresh water, whose deposits form the bed of the Laramie epoch." Of the four principal horizons of Europe, (1) the Urgaptian is not at all represented, so far as known, in North America; (2) the Gault in its upper portion and the Cenomanian in its lower portion are to some extent represented by the Dakota, but (3) the greater portion of Cenomanian is equivalent to the Colorado; and (4) the Senonian is paralleled very well indeed by the Fox Hills group.

The name Post-cretaceous is given by Cope to (1) the Laramie, which has a very characteristic fauna and is not represented in Europe, and the (2) Puerco, which is perhaps represented by the Thanetian of that continent.

The Tertiary epoch is abundantly developed, and from its base upwards the strata contain remains of numerous mammalian types. The parallelism supposed to exist between the various beds of the North American continent and Europe are exhibited in the following table derived from Professor Cope's article:

WEST EUROPE.			NORTH AMERICA.	
Astian.	Pliocene.	Tertiary.	Pliocene.	Equus beds.
Plaisancian.				Megalonyx beds.
Oeningian.	Oeningian.		Loup Fork.	Procamelus beds.
Tartonian.	Falunian.			
Langhian.				Ticholeptus beds.
Aquitanian.	Aquitanian.		White River.	Oregon beds.
Stampian.	Tongrian.			White River.
Sestian.	Parisian.		Uinta.	Uinta.
Bartonian.			Bridger.	Bridger.
Bruxellian.				
Suessonian.	Suessonian.		Wasatch.	Green River.
				Wasatch.

The deductions Professor Cope has drawn from his examination of the various questions involved in these identifications are that (1) "portions of all the faunæ of all the primary divisions of geologic time have been recognized on both the European and North American continents"; (2) these are mostly represented in an inexact manner, as the Coal measures, the Permian, the Laramie, the Maestrichtian, the Eocene, and the Miocene, but (3) several of the restricted divisions seem to be exactly parallel, as the Turonian with the Niobrara, the Suessonian with the Wasatch, and the *Equus beds* with the Pliocene.

In conclusion, a comparison is instituted between the results derived from the examination of the vertebrate remains and those obtained from a study of the fossil plants: (1) The beds determined by Cope from the vertebrate remains to be Upper Cretaceous were identified by Lesquereux from the plants as Lower Eocene; (2) the Lower Eocene of Cope is called by Lesquereux Miocene; and (3) the Middle Eocene of Cope answers to the Upper Miocene of Lesquereux. The discrepant results thus obtained are remarkable and, says Professor Cope, there are only two possible explanations: "Either the animal life of North America has lagged behind that of Europe by one period during past geologic time, or, secondly, the vegetable life of America has been equally in advance of Europe during the same period. In other words, if the plant-life of the two continents was contemporaneous, ancient types of animals remained a period longer in North America than in Europe. If animal life was contemporaneous, plant-life had advanced by one period in Europe beyond that which it had attained in North America."

The necessity for further critical comparisons and study from a large point of view thus becomes obvious, but it must be added that the deductions formulated by Professor Lesquereux are antagonized not only by the vertebrate, but also by the invertebrate remains of the same strata.

ANTHROPOLOGY.

By Otis T. Mason.

INTRODUCTION.

The rank and importance of any science are to be measured not only by the intrinsic value of its subject matter, but by the amount of intellectual activity which it demands and has evoked, and the contribution which its pursuit has made to human progress and happiness. In claiming for anthropology the first rank among the sciences, it is only designed to say that it stands pre-eminent in the grandeur and complexity of its theme. Although calling for minds of the highest order, it is beset with so many difficulties, that men of the greatest genius have been rarely attracted to it, and the beneficence of its results are so little apparent, either in the augmentation of happiness or the increase of solid learning, that even inferior minds have been driven to labor in other fields.

As knowledge becomes more complex its devotees are obliged to be more widely informed, although their cultivation of each subject need not be so profound. The abstract mathematician finds his most arduous labors in the solutions of those problems which have no objective reality. The astronomer, dividing his time between observation and speculation, eliminates the profounder questions of the mathematician. The physicist and the chemist must acquaint themselves with other forces than inertia and gravitation, and in the study of molecular dynamics are compelled to neglect the processes of the astronomer and to accept his results. The retro-action of knowledge, also, is vividly shown in the assistance which the chemist is able to render to the astronomer in the revelations of the spectroscope. To the investigations of the student of matter the botanist adds the vital phenomena, and the zoologist the study of voluntary motion. The anthropologist is bound to acquaint himself with all of these, since man is amenable to all the laws of nature, and, moreover, has ever taken their activities into consideration. His bones and relics are buried in the *débris* of those geological ages which are beset with the greatest difficulties; his body is more plastic than that of any other animal, and the forces of nature act upon him with a greater variety of results. Finally he thinks, he subdues nature. There is scarcely a mineral, a plant, or an animal that might not, with a little strain, find its way into an anthropological museum, as helpful or hurtful to man.

That there is a growing interest in this newest of the sciences is evidenced by several considerations. Among these are the multiplication of private collections, public museums, and journals devoted entirely to the subject. The cursory perusal of a bibliographical list will indicate at once how much more minutely research is ramifying itself in the human subject. The multiplication and perfecting of instruments of precision and the record of many hundreds of observations are evidence in the same direction.

Although the progress and expansion of anthropology are very apparent, it is difficult to indicate their rate in a single year, for the growth of knowledge, like the flight of time, is not marked by trenchant lines. Moreover, many of the best works published in any year do not come to hand immediately, and thus are omitted from every enumeration. Owing to this fact, the summary will have a somewhat narrower range than formerly. It will include all works on American anthropology so far as known, and such publications relative to the subject abroad as have been received by the Smithsonian Institution. The American summary embraces not only works relative to the American races, whenever issued, but also the publications of American scholars in all departments of this science.

The order chosen in the summary is based on the convenience of specialists, rather than upon a scientific analysis of the subject. The following are the headings under which the notes and the bibliography are collected:

I. Anthropogeny.
II. Archæology.
III. Biology of man.
IV. Comparative psychology.
V. Ethnology.
VI. Glossology.
VII. Comparative technology.
VIII. Sociology.
IX. Daimonology.
X. Instrumentalities of research.

I.—ANTHROPOGENY.

No epoch making work like that of Haeckel has appeared during the year. The Duke of Argyle, in a series of papers entitled "The Unity of Nature," develops a scheme of law in nature which is consistent with Christian theism. Dr. Lazarus Geiger's contributions to the history of the development of the human race have been translated into English by David Asher and published by the Trübners. The paper of Dr. Theodore Gill upon the zoological relations of man is a *résumé* of the evolution theory as applied to the human race, in which the author rather states the present condition of the problem than attempts to put forth anything new. The same may be said of the communication of

Dr. Holmes on the distribution of the race, in the transactions of the Academy of Science of Saint Louis. Prof. Gabriel de Mortillet, in his *Précurseurs de l'homme*, inclines to the opinion that a rude, stone implement-using race of apes may have preceded man, and, therefore, that the flaked flints from the Tertiary could have been in use by these precursors of man. The pedigree of man is also discussed in the publications of Letourneau, Nadaillac, Parker, Perier, Radcliffe, Ramon, Vaughn, and Ward. The most important work that has appeared upon the subject in our country is Professor Winchell's "Preadamites." The title of the volume is rather ill-chosen, for the reason that it is both misleading and too narrow. In addition to defending the view that the biblical record relates mainly to the semitic peoples, and that the man of archæology is almost outside of its purview, Dr. Winchell has gone over the ground of ethnic distribution with great care, and presents a very clear statement of the present condition of the inquiry.

II.—ARCHÆOLOGY.

Great activity has characterized the archæologists during the year. In the United States the subject is fostered in many ways. The Smithsonian Institution and the National Museum, co-operating, have their collectors and correspondents in every State and Territory where aboriginal relics and remains exist. The Bureau of Ethnology, lately organized under Maj. J. W. Powell, has rendered very efficient aid among the Pueblos. Institutions in the States are hardly less energetic in the work. In Massachusetts, the Archæological Institute of Boston, the Peabody Museum of Cambridge, and the American Antiquarian Society have all put on record labors of permanent value, as will be seen in the appended list of works. The American Museum in New York is now the repository of Mr. Terry's collection of American antiquities, besides several others illustrating savages in various parts of the world. The Philosophical Society of Philadelphia and the Academy of Natural Sciences publish occasional papers. In Ohio the Western Reserve Society at Cleveland, the Cincinnati Society, and the Madisonville Society are actively engaged in explorations. The last-named body have published in pamphlet form a detailed account of one of the most thorough investigations ever made in American archæology. The State geologist of Indiana includes in all his reports an account of mound explorations made during the year. The same is true of the Wisconsin and the Minnesota Historical Society.

The Davenport Academy in Iowa and the Saint Louis Academy in Missouri are among the most active of our State societies.

The activity in the study of archæology does not end her e. The rage for antiquities among rich gentlemen, both east and west, has put a high value upon aboriginal relics, and there are many archæological treasures in these private museums. It is a cause of regret, however, that this cupidity for relics has started up the race of Flint Jacks to flood the country with worthless counterfeits.

Archæology is further patronized and fostered by several periodicals, as the *American Antiquarian*, the *American Naturalist*, the *Kansas City Review*, the *Magazine of American History*, the *American Art Review*. It would be impossible to speak of all the separate productions in this field of research; a few only will be mentioned that are likely to influence public opinion to a large extent.

M. Florentino Ameghino has been very fortunate in discovering what he regards the vestiges of prehistoric man in the Pampas of Buenos Ayres, an account of which he publishes in the first number of the *Revue d'Anthropologie* for 1880. It is a cause of congratulation that three gentlemen in the City of Mexico, Senores Chavero, Orozco y Berra, and Icazbalceta have taken up the study of their own antiquities on the spot, in an intelligent manner, and are publishing the results to the world in the *Anales del Museo Nacional de Mexico.*

The extremes of archæological interpretation are represented by two expeditions sent out to Central America. The Lorillard party, under M. Désiré Charnay, is the first in the field, and an account of their results will be found in the *North American Review* for Sept.–Dec. This mission embodies the Prescott school of archæologists who hold that the Aztec and the Maya were something quite above our modern savages. The Archæological Institute stands for the opposite view, as set forth in the writings of Mr. Lewis H. Morgan and of Mr. Bandelier, the agent of the Institute. Both parties are in severe earnest, and naught but good can come from hearing both sides.

In England the debate still goes on as to the geological significance of certain flint implements discovered in the caves and brick earths. Are they post-glacial, intra-glacial, inter-glacial, or ante-glacial? The account of the discussions upon the subject will be found in the files of *Nature.* The appearance of Mr. Dawkins's "Early Man in Britain" is the immediate cause of the controversy.

Not less interesting and important is the volume of Principal Dawson on "Fossil Men and their Modern Representatives." The purport of the book is to connect aboriginal life as it has been enacted before the author's eyes in Canada with the revelations of archæology. From these data, Dr. Dawson seeks to reconstruct ancient society in Europe.

The papers of Mr. William McAdams are of especial interest as showing what excellent work a farmer can do who is willing at idle times to take his teams and men and to make careful explorations. Mention should also be made of the labors of the Rev. S. D. Peet, who has managed the *American Antiquarian* under great difficulties and without salary, until it has now reached the third volume. The work upon the mound pottery of Missouri, prepared by Messrs. Potter and Ebers, and published by the Academy of Natural Sciences of Saint Louis, is a splendid work in every respect—text, illustrations, and maps. The explorations described were made in the southeastern corner of the State, at New Madrid, a locality singularly rich in mound relics. Prof. John T. Short, of Columbus, Ohio, has published during the year a volume entitled "The North Americans of Antiquity," in which he has brought together at great pains the results of explorations up to our day. It would not be too much to say that it is now the best manual of American archæology. In the Smithsonian Annual Report for 1879, published in 1880, there are many papers upon archæology. The one most worthy of careful perusal upon this subject is that by Mr. Walker upon the shell heaps of Tampa Bay, Florida. The author reviews adversely Professor Wyman's theories of ancient cannibalism, and presents other methods of accounting for the phenomena.

Wiener's "Perou et Bolivie" is a gorgeous work, whose material was collected at the expense of the French Government by Mr. Wiener, who spent two years exploring the graves and ancient monuments of the land of the Incas.

III.—BIOLOGY OF MAN.

The title of this section is somewhat elastic; indeed the *École d'Anthropologie* of Paris divides its contents between two professors: M. Mathias Duval, who, under the subject of anatomical anthropology, delivered a course of lectures upon anthropogeny or comparative embryogeny of the vertebrates during the last winter, and Dr. Paul Topinard, who, from the chair of biology, lectured upon anthropology in respect of the living; inasmuch, however, as the same individuals are engaged frequently in the study of man, structurally and functionally, and the latest text-books take strong ground that the two methods of research must be prosecuted simultaneously, it is found convenient to include within the same theme all those investigations which regard man from the side of zoölogy. The Biological Society of Washington has taken the same ground, in embracing within its membership osteologists and conchologists, as well as embryologists and physiologists.

A noteworthy fact in this portion of anthropology is the slow but sure encroachments which methods and instruments of precision are making upon the different parts of the human body. In 1786 was published, in Paris, Pierre Camper's "*Dissertation sur les différences réelles qui présentent les traites du visage chez les hommes de différents pays et de différents âges.*" The facial angle has received more careful scrutiny at the hands of Geoffroy St. Hilaire, Cuvier, Cloquet, Jacquart, Broca, and many other distinguished anatomists. The cubage of the cranium, the situation and direction of the *foramen magnum*, the occipital, basal, and nasal angles, and the cranial indices have assumed an importance even greater than the facial angle. The scapular index, thoracic index, pelvis, femur, tibia, and even the digits, are not without their value in the problem.

The great difficulty of collecting the skeletons of any race in sufficient numbers and well authenticated, has driven the anatomists to devise methods of obtaining measurements upon the living. The British Association has done very much towards establishing standards of comparison in this regard. Nor are the French very far behind in the work.

The brain, no less than the cranium, continues to be the subject of absorbing interest. The comparative anatomy of the encephalon holds out the hope that here lies the path to the solution of the problem of man's ancestry and origin. On the other side, among these meandering labyrinths, are sought the secrets of the connection between material and spiritual existence. In the bibliography appended to this summary, studies on the brain are accredited to Amat, Bordier, Ducatte, Duval, Fowler, Spitzka.

The work of examining the skeletons or the living bodies of men, however, has a decided rival in the science of embryology. The grand generalizations of Haeckel, in his "Evolution of Man," however faulty in detail, as all such comprehensive speculations must necessarily be, have kindled a vast amount of interest in human ontogeny. The researches of M. Mathias Duval, successor to the renowned Broca, upon the origin of the cranial nerves, will be found reported in the *Journal de l'Anatomie et de la Physiologie*, mai–juin and septembre–octobre, of the past year.

IV.—COMPARATIVE PSYCHOLOGY.

The question of the place of inductive psychology in the general scheme of anthropology is as yet unsettled. Taking biology in its widest sense, as including life in all its manifestations, there could be no objections from any quarter to including the comparative psychology of man and the lower animals within the purview of this comprehensive subject. The reason for creating a class distinction in its favor is that there is a separate group of men at work in this area. The problems and methods belong to several subclasses. For instance, assuming the difference between the mind of man and that of the lower animals to be one of degree rather than one of kind, or, rather, to consist in a more complicated and subtle organization of the same elementary principles, and not in the difference of its constituents, it is held that the careful scrutiny of the manifestation of reason, feeling, and volition all along the line of the zoological scale will lead up to a correct apprehension of mental and spiritual phenomena in man. Again, the question arises whether the intricate system of powers, emotions, and desires are not derived by inheritance and modification from simpler faculties. A very interesting series of observations have been set on foot by Francis Galton as to the connection of memory and imagination with time and space. A fourth set of inquiries relate to the order and method by which mentality is manifested in childhood and youth. Finally, this portion of anthropology has its bitter controversial side. Between the atheistical materialists, the agnostic materialists, and the theistic dualists there still exists that personal prejudice which blinds the eyes of the observer and confounds right thinking.

V.—ETHNOLOGY.

The term ethnology is retained for all those descriptive and philosophic publications which relate to the groups of men called tribes, races, peoples, the individuals of which recognize in one another a common bond of union and an entire absence of prejudice. Ethnography is a narrower word, applying only to monographs of different peoples.

The descriptive portion of ethnology is certainly the most important part of anthropology. When we reflect that a very large part of the immense collections of "materiaux pour l'histoire primitive et naturelle de l'homme" contained in such works as Spencer's Descriptive Sociology are falsehoods or mistakes, we tremble for the deductions that are to be erected upon such a crumbling base. This is not meant to disparage the great work of such men, but to enjoin the utmost caution upon future observers. It has frequently occurred to the present writer that we should have an account of the "personal equation" of each narrator before admitting his facts into the general fund of anthropologic truth.

It is very difficult to single out special works in ethnology, since there is scarcely a portion of the habitable globe that has not been visited during the past year. No labor undertaken, however, will compare with the elaborate investigations which have been prosecuted among the Indians of the United States, under the patronage of General Walker, of the Census Department. The task of making the inquiries and working up the material has been intrusted to Maj. J. W. Powell, of the Bureau of Ethnology, and it is safe to say that there is not a little band of Indians in our territory that has not been approached by an intelligent ethnologist. The war in Afghanistan, in Zululand, and the encroachments of the Russians upon the southern portions of their dominions have all been fruitful of valuable ethnologic results. Among the enlightened nations of Europe there is the greatest activity in searching out the racial affinities of the present populations. Works of permanent interest have also appeared upon China, Japan, and the races of Oceanica.

A very valuable paper upon French and Indian half-breeds, from the pen of Dr. Havard, will be found in the Smithsonian Report for 1879.

VI.—GLOSSOLOGY.

The mere acquisition of a language, or even the accurate study of its phonology, its etymology, and its syntax, is not a part of anthropology. Linguistic anthropology has reference, first to the origin and life history of language as a whole, and, second, to the comparative study of the languages of the globe as a means of grouping its peoples. From the point of view taken by the student of the natural history of man, all tongues are alike useful, all are part and parcel of a complex organism or links in the glottic chain. Inasmuch as the languages of savage and barbarous races are never acquired either for the purposes of traffic, or as a part of polite learning, it follows that all vocabularies, syllabaries, or collections of sentences gathered among such people are materials of anthropology.

Among our North American Indians there is at present great diligence in collecting linguistic material. The missionaries who have labored with the greatest success among them have been those who have discovered that the compliment paid to a tribe in the acquisition of their language returns with interest to the teacher in the form of increased confidence and attention. Almost the entire Scriptures have been translated into the speech of the civilized tribes. The labors of Riggs, Dorsey, Vetromilye, bear witness to this fact, and furnish the philologist with some of his best material.

The work of collecting Indian. vocabularies, grammars, and dictionaries set on foot by the Smithsonian Institution is continued with great zeal by the Bureau of Ethnology. Mr. James C. Pilling is preparing a complete bibliography of North American Indian linguistics, which will enable the student to investigate each tribe in the whole body of its literature. Mr. Albert S. Gatschet continues his labors in the languages of the California tribes, and will produce the coming year two large volumes upon the Klamath.

A glance at the bibliography accompanying this paper will show that the same activity has characterized those who have investigated the languages of other parts of the world. Especial attention might be called to the researches of Hovelacque, Keane, Oppert, Powell, Sayce, and Whitney.

The work, however, that has attracted most attention in this direction is that of Col. Garrick Mallery upon the sign language or gesture speech of mankind. The author has not yet completed his researches, and therefore his work cannot be fully appreciated. The following tentative publications will show the compass of the undertaking. The first attempt to present the subject publicly was at the Saratoga meeting of the American Association, in 1879, an account of which will be found in the volume of proceedings published in the following year.

A paper with the same title, not identical with the above, but containing the greater part of it, and specially designed for circulation among officers of the Army and Navy appeared in the *United Service*, vol. ii, No. 2, Philadelphia, February, 1880, pp. 226–243.

In the *American Antiquarian*, vol. ii, No. 3, pp. 210–228, the author continues his studies under the title, "The Sign Language of the Indians of the Upper Missouri in 1832." This was a translation and discussion of the gesture signs reported by Prince Maximilian von Wied Neuwied as in use among the Aricaras, &c., in 1832–'34.

The most thorough work of Colonel Mallery is the "Introduction to the Study of Sign Language among the North American Indians as illustrating the gesture speech of mankind." The chief object of the work is to explain the principles of the sign language in such manner as to properly direct research, and to furnish for observers forms of description and graphic illustration, so as to secure accuracy and uniformity in collecting material for a larger work. Reviews of this volume will be found in *The American Journal of Philology*, i, No. 2; *American Naturalist*, May; *Penn Monthly*, October; *Academy*, May 22; *Nature*, June 3; *Theosophist*, Bombay, August; *China Daily News*, Shanghai, May 17, 1880; *Behm's Geographische Jahrbuch; Globus*, 87, No. 17; *The Pioneer*, Allahabad, January 15, 1881; Swansea meeting of the British Association, report, pp. 630, 635.

A subsequent work, printed for collaborators only, issued in Washington, is entitled "A Collection of Gesture Signs and Signals of the North American Indians, with some comparisons."

VII.—COMPARATIVE TECHNOLOGY.

It is difficult to find a term accurately definitive of what is intended to be included in this class. Perhaps Mr. Spencer's "operative" category comes nearest. At any rate the term technical anthropology embraces the description of the materials, implements, processes, methods, agents and agencies, observances and results which enter into the activities of man, in peace and in war, at every step of his social progress. These activities are of many kinds, as diversified, indeed, as human needs and desires multiplied by the varieties of material and environment.

The discussion of this portion of anthropology is quite apart from the consideration of race. Stone, shell, wood, textile, skins, clay, and metal work have each passed through an elaboration which has kept pace with the evolution of culture. The works upon this subject during 1880 have included meteoric iron in its relation to technique and the history of civilization, aboriginal use of copper, the origin of metallurgy, composition of ancient pottery, savage and civilized warfare, agricultural fertilizers used by the Indians, jade workers, ancient commerce, and the origin of the plow and the wheel-carriage.

Two works by our own countrymen deserve especial mention in this connection. The Smithsonian Institution has published as a brochure an article by Dr. Edward H. Knight upon the savage weapons at the Centennial Exhibition, taken from the report of 1879. The work is profusely illustrated, and is very suggestive of many of the "missing links" in the growth of the implements of militancy. The other work referred to is by the Hon. Lewis H. Morgan, entitled "A Study of the Houses of the American Aborigines, with suggestions for an exploration of the ruins of New Mexico, Arizona, the valley of the San Juan, and in Yucatan and Central America, under the auspices of the Archæological Institute of America." Mr. Morgan's belief with reference to all the remains of our country whether fossal, aggeral, or mural, are well known. The gentile system being given, the house, be it teepee, bark lodge, long-house, pueblo, or stone palace, is the natural outcome of the organization. The student of comparative technology cannot afford to omit this publication.

VIII.—SOCIOLOGY.

Anthropology is not concerned with individuals. It does not inquire how he or they acted or thought; that is biography or history. It is ever asking how they were accustomed to act. It does not seek to know *quid fecerit* or *quid fecerint*, but *quæ solebant facere.* When men are accustomed to do a certain thing, they act in groups, at specified places, and during certain seasons. Social anthropology inquires into the regulative forces of society. The propagation of the species and self-protection lie at the foundation of the family, the guild, and the state, representing children, craft, and power. Beneath each of these lies an unique principle, commonly overlooked by writers on sociology. A combination of families does not constitute a guild or a state. The family, as such, will never become more complex than the ends of procreation, nursing, and rearing of children demand. A combination of guilds does not constitute a government. The same men, women, and children who may be classified as families will be found arranged in guilds upon entirely different rules. The same is true of the government, both militant and industrial.

The student of sociology, therefore, may set before himself a great variety of problems. The discussion of the family, including those questions of natural forces which affect the increase or diminution, occupies a prominent place in sociology. The progress from promiscuity through the marriage of consanguines, then upward to the various forms of polyandry and polygyny to monogamy, though not yet worked out, has received important additions in the works of Lorimer Fison, and Dr. J. Bertillon.

The question of industrial coöperations has as yet received little attention. Mr. Herbert Spencer gives a large place in his descriptive sociology to the regulation of industrialism. A very entertaining and important chapter in human history will be the narrative of the source and vicissitudes of human industrial classes.

On the other hand, the history of militancy has been over-written. In the early part of its career our race was at war with nature as well as with itself. Man went forth to slay the beasts of the field, the fowls of the air, and the fish of the sea for food and clothing. All his tools were weapons, all his methods were warlike, and the same social organization served both for the slaying of enemies and the pursuit of life's necessities. In the upper grades of culture, however, this is different, when the change of function demands a corresponding change of social structure.

The study of sociology is so intimately connected with human happiness that there is no lack of interest or improvement in this department of anthropology. Of special importance are the publications of Bandelier, on the social organization and mode of government of the ancient Mexicans; Bertillon, on human statistics in France; Flower, on fashion in deformity; Gore, on the development of deliberative government; Powell, on the Wyandotte Government; Royce, on the method and chronology of the extinction of the Indian title: and Yarrow, on mortuary customs.

IX.—DAIMONOLOGY.

The word "religion" has had such a variety of meanings that some anthropologists never employ it. The term "religious" applies almost universally to persons, so the phrase "religious anthropology" would not convey the meaning intended. At the risk of introducing a neologism, the term "daimonology" (from Δαίμων,—a god, soul, or destiny,) is employed to include all observations and discussions concerning the belief in spiritual beings, the conduct of men in view of their belief, the paraphernalia by means of which these beings are approached and appeased, and the body of dogmas and stories which have grown up around the various phases of a faith.

Two facts are noticeable in view of the vast amount of earnest study which has been bestowed upon this subject. First, it is now well known that there are bodies of myths among every people as full of pathos and sublimity as those of Greece and Rome. Major Powell is doing excellent work in the way of collecting these stories among our own Indians. The Folk-lore Society of Great Britain, as well as similar associations in France and Germany, were organized for the purpose of publishing in permanent form the supernatural stories of uncultured peoples.

In the bibliographical appendix will be found allusions to "Norse mythology," flower fairies, wolf-reared children, the religions of India, Polynesia, Ancient Assyria, and Mexico, the cult of the dead, lore of the heavenly bodies, and of animals, creation myths, sacred books, and the origin of religion. Major Powell's vice-presidential address before the section of biology, at the Boston meeting of the American Association, was a discussion of mythologic philosophy, in which the desire to philosophize concerning the causes of natural phenomena was considered to be the fundamental principle of all religions.

X.—INSTRUMENTALITIES.

Each science has not only its field of operation where it gathers its materials, but its storehouses where they are garnered and its media of products before the world. Anthropology also has its implements of research, its museums, and its journals.

The instruments of precision are mostly confined to the department of biology. The methods of collecting and recording facts for future reference are of immense importance in prosecuting any study. The Smithsonian Institution and the Bureau of Ethnology use card catalogues in their work, so that information is always accessible. It is no disparagement to say, however, that in the system pursued at the Surgeon-

General's Office in collating the Index Medicus and the great catalogue of the library, the plan of carding knowledge has well nigh attained perfection.

The subject of anthropology is discussed, first of all, in societies devoted entirely to this science, or one of its branches. The principal ones are the Anthropological Institute of Great Britain and Ireland; the Société d'Anthropologie de Paris; and the Anthropologische Gesellschaft of Germany. Societies also exist and publish journals in Berlin, Vienna, Florence, Madrid, and Washington. Secondly, international congresses are held in various cities of Europe. Pre-eminent among these are the International Congresses of Anthropology, Ethnology, and Prehistoric Archæology, Congrès des Américanistes, and the Congrès International des Sciences Anthropologiques. Thirdly, the great national scientific gatherings, answering to our own American Association, have each a subsection of anthropology, and very many valuable papers appear in their transactions. Fourthly, papers of permanent value in the study of man are read in the great number of local societies in our larger cities and abroad. Fifthly, in addition to the journals, bulletins, transactions, proceedings, and contributions of all these associations, the popular science periodicals, as well as the best literary monthlies and quarterlies, give place each month to at least one article upon anthropology.

To go over all this material requires a vast expenditure of time, more than one individual can command. Already, therefore, the science begins to have its specialists, who have given up the hope of occupying the entire field and have contented themselves with a circumscribed area.

The following bibliographical list does not claim to be exhaustive. It represents pretty accurately what Americans are doing and what is being done for America. The voluminous publications of the Archiv für Anthropologie, although appearing rather late, are indispensable to one who would prepare an exhaustive bibliography of our theme. The abbreviations used throughout this paper are those which have been adopted at the Surgeon-General's Office, in the preparation of the great medical catalogue.

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[The meeting at Boston was the largest ever held. The papers, a list of which is given below, were exceptionally valuable. The president's address will be found recorded under the name of Maj. J. W. Powell.]

1. Ethnology of Africa. A. S. Bickmore.
2. Myths and folk-lore of the Iroquois. Erminnie A. Smith.
3. Prehistoric altars of Whitesides County, Ill. W. C. Holbrook.
4. Theory of primitive democracy in the Alps. D. W. Ross.
5. Ancient mounds near Naples, Ill. J. G. Henderson.
6. The mounds of Illinois. Wm. McAdams.
7. Prehistoric and early types of Japanese pottery. E. S. Morse.
8. Scheme of the tenth census for obtaining statistics of untaxed Indians. Garrick Mallery.
9. Stone implements from the river drift of New Jersey. C. C. Abbott.
10. Indications of pre-Indian occupancy of the Atlantic coast of North America subsequent to that of palæolithic man. C. C. Abbott.
11. The probable existence in America of the prehistoric practice of trepanning in the cutting of rondelles or amulets from the skull. R. J. Farquharson.
12. The Dacotah tribes. Gen. H. B. Carrington.
13. Textile fabrics of the ancient inhabitants of the Mississippi Valley. J. G. Henderson.

AMERICAN ASSOCIATION—Continued.

14. Engraved tablet from a mound in Ohio. W. J. Knowlton.
15. Japanese caves. E. S. Morse.
16. Ancient agricultural implements of stone. Wm. McAdams.
17. Alabaster quarries, flint mines, and other antiquities of Mammoth, Wyandot, and Luray caverns. H. C. Hovey.
18. The classification of kindred by the North American Indians. J. W. Powell.
19. On the Iroquois languages. Erminnie A. Smith.
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21. Remarks on the mound-builders. J. F. Everhart.
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23. Conventionalism in ornamentation of ancient American pottery. F. W. Putnam.
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26. The topographical survey of the works at Aztalan, Wis. S. D. Peet.
27. The military system of the emblematic mound-builders. S. D. Peet.
28. Improved stereograph for delineating the outlines of crania. A. S. Bickmore.
29. Feeling and function as factors in human development. Lester F. Ward.
30. The uses of the "chungkee-stone." Alfred M. Mayer.
31. Relation of the archæology of Vermont to that of the adjacent States. Geo. H. Perkins.
32. Exhibition of some gambling games of the Iroquois. Erminnie A. Smith.
33. Parturition in a kneeling posture as practiced by the women of the mound-building and stone-grave peoples. C. Foster Williams.
34. The antiquity of man in Eastern America geologically considered. Henry C. Lewis.
35. A comparison between the shells of Kjökkenmöddings and present forms of the same species. E. S. Morse.
36. Antiquities of Onondaga County, N. Y. W. M. Beauchamp.

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[The contents of this volume are distributed among the names of their authors.]

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ABSTRACTS OF THE SMITHSONIAN CORRESPONDENCE RELATIVE TO ABORIGINAL REMAINS IN THE UNITED STATES.

By Otis T. Mason.

Very important information relative to the antiquities of our country continues to appear in the correspondence of the Smithsonian Institution in response to Circular No. 316. That which relates to relics is preserved by Professor Charles Rau. It only remains, therefore, here to collect and publish that which refers to the permanent remains of the country, such as shell-heaps, mounds, circumvallations, pueblos, &c. The diligence and care with which the locations and characteristics of such structures are marked and preserved by the intelligent nations of the Old World should be an example to us with reference to our own country. Very few persons realize the preciousness of such a statement as "There are no ancient remains whatever in my county,' or "There are shell-heaps, mounds, or ancient earth-walls in such a place." It is designed by the Institution, when the permanent work on archæology is published, to have no blank spaces whatever; but to be able to give an intelligent account of every county and even every township in the United States.

Barnard, D. Mentions an old graveyard near San Buenaventura, Cal., where, under large flat bowlders, lay skeletons with chipped implements, beads, mica crucibles, red paint, mortars and pestles, and vases or urns.

Billings, Melvin. Sends to the institution specimens from mounds and graves near Marion Centre, Kans. Among them was a tablet found 8 feet below the surface, on the second bottom, beneath a deposit of clay, surrounded by about a bushel of ashes, shells, and broken pottery.

Brace, A. L. Has forwarded description and drawing of a flint flake found in an excavation 3 feet under the surface in a yellow bed of clay, at Amazonia, Andrew County, Missouri. The implement is 14½ inches long, 5½ inches wide, and 1 inch thick in the widest part. Mr. Brace also describes other implements in his possession.

Bush, Miss Jennie R. Gives notice of the destruction of the museum of the California State normal school, February 10, 1880; also an account of a collection of stone implements from Coyote and Guadaloupe Rivers, California. [The Smithsonian Institution is in receipt of letters constantly, giving account of the destruction of valuable collections by fire. It has been the policy of the Institution to foster private and local museums in every possible way; but it is an irreparable loss to science when a large and unique collection is thus destroyed.]

CHASE, ALEX. W. Mentions the site of a large buried village of stone houses on the mill-site of the Grand Central mine, near Tombstone, Ariz. In one house were seven skeletons, one of which had on the wrist a bracelet of ivory or bone beads. In one of the houses were found stone tools, mortars, &c.

CLICK, THOMAS M. Reports that there are many ruins in Colorado, near Dolores, in La Plata County. The largest seen by the writer is situated on Animas River, in Taos County, New Mexico. The buildings are in groups. Two of the largest were five stories high, each about 100 to 120 yards square, built of stone and adobe mortar. The walls at the base are 3 feet thick, with small openings or windows 6 feet above ground to admit air, but not large enough to allow a man to pass through them. The floors were constructed by laying large cedar logs across the wall for joists, and by covering these with cedar splits and mud. The buildings stand in or near the centre of what was a town or village. The other houses were much smaller and built of small bowlders and mud. There are no cedars in the region at present so long and so large as those in the houses. Many remains of cliff-houses are found on the bluffs, some on the Dolores River, in La Plata County. They are built of sandstone and mud. Pottery, arrow-heads, corn-cobs, charcoal, stone axes and hammers, and skeletons have been found in these ruins. The burying-grounds are generally laid out in a regular manner, the bodies being placed with the head to the west. Two skeletons were unearthed on the Rio Mancos, near Mancos P. O., La Plata County, that were lying one across the other, with an earthen jar under the head of each.

CONWAY, JOHN W. Describes a visit to the old abandoned pueblo of Cuyamanque, which was one of the first built in New Mexico. The ruins are about four miles below the pueblo of Tesuque, on the west bank of the same river. This pueblo was destroyed in 1697, by General Diego de Vargas. Tesuque, Cuyamanque, Pojuaque, Nambe, San Ildefonso, Santa Clara, and San Juan had raised an insurrection, and collected together on a high mesa to fight the Spanish forces. They were completely routed, being driven across the Rio Grande, either to the cliff-houses on the west side of the Ildefonso, or over towards the Navajos country. The pueblos of Cuyamanque, Pojuaque, and Nambe were destroyed by General Vargas. Twenty years afterwards the Indians were brought back to their old dwellings, excepting those of Cuyamanque, who were scattered among the other pueblos. Digging around this ruin, Mr. Conway discovered specimens of painted pottery, and stone implements.

CUSHING, F. H. Gives information that ancient excavations, supposed to be turquoise and jade mines, near Zuñi, N. Mex., turn out to be quarries of sacred paint. The principal source of supply for these precious stones lay across the Rio Grande, far north toward Santa Fé. The Zuñi myth to account for those stones, as well as for a peculiar black bead which they highly prize, and for salt, is as follows: Centuries ago there was a great cacique who lived in the Sierra Azul, north of San Mateo. Wherever he urinated, the drops became beautiful blue and green stones. When the Zuñis Aconutes came to know of this they encamped so thickly around the cacique that the stench drove him away west on the Zuñi Mountains, where he stopped to make water; but he was in such haste that the stones formed were not pure chalchiuite. This side the mountain he met the woman whose urine was transformed into salt. He settled down with her a mile or two east of Zuñi; but again fled in anger from his house, around which the people flocked. This time he went south to the desert, and there lived with his wife, her urine forming the lake of salt ("Salina"), which is to-day the source of supply to the Indians. The woman becoming angry with the cacique, drove him into a cave in the White Mountains of Arizona, whence he disappeared forever. Since then, a strong wind has blown from the cave sufficient to extinguish the torches. Nevertheless, the people felt their way in through the darkness, and found the precious stones. On this account a part of them were turned black, and large flies were caused to live about the place in summer. The people, however, have persisted in going there, and found among other things the discolored beads worn by the Zuñis. At this place, the cacique's urine was changed into perfectly finished and drilled stone, and in that condition they are still found. The cave in question is like that of Silver City, and identical in use with the sacred dance cave of Zuñi, where paraphernalia are placed, and costly sacrifices of chalchiuites are now made.

DOVER, THOMAS. Describes frog pipe and charred cloth from a mound in Butler County, Ohio.

EARHART, JOHN S. Witnessed the demolition of a mound caused by the construction of the Cincinnati, Hamilton and Dayton Railroad, one mile south of Post Town station, and two miles north of Middletown, Butler County, Ohio. The mound was in the level plain of the first bottom land of the Miami River, 30 feet in base diameter, and 15 feet high. Two-thirds of the mass were removed 3 feet below the original surface. In the centre, rolls of textile fabric were found, varying from the fineness of three-ply carpet to the coarseness of a gunny bag, and preserved in shape by the moisture of the earth. These rolls were 6 inches in diameter at first, but were much broken by removal, and in coming in contact with the air were wafted away by the slightest breeze. Specimens were preserved by hermetically sealing them, while damp, between pieces of glass. A spear-head, 8 inches long and 2 inches wide, was also unearthed. On further examination among the burnt clay and charcoal, a few bones of a human hand were recovered.

EATON, D. H. Reports the collection of antiquities from Bridgewater, Mass.

EVANS, W. W. At Pompeii, Italy, discovered by actual measurement that the gauge of the ancient chariots was nearly that of our modern wagons, viz, about 4 feet 9 inches. He also believes from the charred condition of window and door jambs that Herculaneum and Pompeii were overwhelmed in about half an hour; one by a river of lava, and the other by a shower of ashes and stone.

EVERHART, J. F. Reports a mound in Brush Creek Township, Muskingum County, Ohio; trees, apparently in rows, and arranged quincuncially were growing on the mound. Just below the trees was a stone wall. Across the south end a pavement of loose stones extended, and one of flagging occupied the middle, on which were ashes and bones of man and of animals. In the mound were found skeletons of great length.

HARRIS, GEO. H. Finds a rich field of antiquarian research in the ridges running through the counties bordering on the south shore of Lake Ontario.

HENDERSON, J. G. Has made excavations in Naples mounds, Illinois. Full report in preparation.

JONES, GEORGE C. Describes a ploughed field near Brookfield Centre, Conn., in which a great number of flint chips and small arrow-heads of white quartz and feldspar were found. The material from which these were made was brought from a great distance. A quarter of a mile from this field a mound 15 feet long, 12 feet wide, and 3 feet high was discovered; but on opening it, Mr. Jones found no remains. A ceremonial axe was dug up near Brookfield, in a swamp.

KERNE, Lieut. L. M. Sends an arrow-head from the old French fort on the bank of the Beaufort River, near Port Royal, S. C. This fort was built by the expedition that landed at Port Royal in 1562, under Jean Ribault.

LARMOUR, J. J. Reports a great many small mounds in the neighborhood of Battle Creek, Michigan; but few contain any bones. Some have been explored.

LOCKE, W. M. Describes a group of small mounds near Marshall's Ferry, White County, Illinois, situated on the highest point of land. The largest is 15 feet high and 35 to 40 feet in base diameter. Within the mounds were slab graves, containing the bones of children. Mr. Locke also found pots which contained small human bones. In one large cist the remains of an adult female were discovered. Drawings of pottery and relics accompany the letter.

LOVE, A. C. Mentions a group of unexplored earthworks in Ascension Parish, La.

LOW, CHARLES F. Reports upon the explorations at Madisonville, Ohio, mentioned by Dr. Metz, having exhumed 370 skeletons and explored 175 ash-pits.

MACLEAN, J. P. Mentions several pieces of cloth from a mound in Butler County, Ohio.

METZ, C. L. Reports the opening of twenty-five circular pits in a cemetery near Madisonville, Ohio, containing ashes, animal remains, implements of flint, stone, and bone. The depth of the pits, from 4 to 6 feet; the width, 3 feet; the sides and bottom show no evidence of fire. Some contain likewise large sherds of pottery and unio shells. The contents are usually as follows: One to three feet ashes, containing bone, flint, and some stone implements, with sherds of pottery and animal remains. Above this is a heavy layer of clay loam, 1 to 4 feet thick. None of the implements show the action of fire, many fine bone awls having been found; nor are the animal remains charred at all. A few burnt bones were probably thrown in with the ashes. (Detailed reports, in the Journal of the Cincinnati Society of Natural History, vol. iii, pp. 40–68; 128–139; 203–220.)

MORGAN, B. Describes the Des Moines Valley as rich in mounds and relics. He has excavated more than one hundred works in different parts of the State. From these have been collected stone implements and pottery. In some of the works examined there are indications of great age. The writer, has opened mounds near Richland, Iowa, measuring 250 feet in base circumference and 2 feet in height. At a depth of about 20 inches pottery was found, some of the vessels very large and shaped like a common dinner pot. Around the rim frequently occurs a narrow band, divided into triangular spaces, which are filled with parallel lines running vertically and horizontally in the alternate triangles.

PALMER, EDWARD. Has forwarded a mummy from Monterey, Mex., presented to the Smithsonian Institution by Don Ignacio Galerido. It was procured from a cave near Coyote, in Coahuila, latitude 25° 15′, longitude 103 west from Gr., near the western border of the State. It is encased in a garment much like that of the ancient Peruvians. In the States of Durango and Chihuahua, Mex., there are said to be caves containing Indian remains.

PRIME, FREDERICK, JR. Describes a mound at Waynesborough, Augusta County, Virginia, 500 feet long, 250 feet wide, and 40 feet high, close to the Chesapeake and Ohio Railroad, on the south side, and 2¼ miles west of Rockfish Gap tunnel.

RANSBURG, W. C. Is making a thorough survey of the La Porte group of mounds in Indiana.

REDDING, B. B. Mentions an obsidian spear-head, 7 inches long, 3½ inches wide, found beneath the drift and boulders which compose the placer diggings. Mr. Redding regards this implement as an evidence of the existence of pliocene man in California.

REINSCH, A. Explored two mounds on Walnut River, in Cowley County, Kansas. They are 30 rods apart, 30 feet in diameter, and at present 18 inches high. They were originally between 3 and 4 feet high. A trench 3 feet wide was dug to the centre of one of them. Bones, potsherds, charcoal, jasper chips, and arrow-points were found at a depth of 6 feet, or about 4 feet below the surface. Mr. Reinsch also sends drawings of implements, among them a hollowed grinding-stone of whitish limestone.

ROBINSON, A. P. Sends a map of Coffey County, Kansas, on which are marked the locations of antiquities. Along the summit of the bluff, on Wolf Creek, many stone heaps are found, containing shells of unios, such as now live in the Neosho River, which is at present a mile away. At the foot of the bluff, by the cutting of the Missouri, Kansas and Texas Railroad, many arrow-heads were unearthed. By digging a ditch, what was possibly a cremation site was passed through, and a few knives and arrow-heads were found. The ashes, &c., were from 4 to 5 feet below the surface, and over the sites were growing oaks 3 to 4 feet in diameter. In this locality many fragments of pottery were discovered, but only a slight investigation was made.

SHIPPEN, EDWARD. Mentions a mound in Ballard County, Kentucky, 1 mile from the Ohio River, from which he took 437 arrow-heads, 1 spear-point, 7 flint axes, 9 pipes, 24 vessels of clay, and many pottery fragments. The letter is accompanied with drawings of implements.

SPRAY, S. J. Reports that the region around Marysville, Blount County, Tennessee, is rich in relics of the Mound-Builders.

STRONG, LORENZO. States that no mounds or earthworks occur near Strongville, Cuyahoga County, Ohio. Stone implements are found in abundance.

SWAN, JAMES G. Sends to the National Museum a carved seal club, or *tinethl*, as it is called by the Makah Indians. This specimen was made by a young Indian of the Clyoquot tribe, on the west coast of Vancouver's Island, B. C. His name is Artlyu, or Benjamin. He is a son of Cdakanim, a chief of the tribe, and a great grandson of Wikananish, the great chief mentioned by Mears and other early navigators. This young man was one of the party who saved the captain and crew of the American bark General Cobb, wrecked off Clyoquot last winter. A photograph of Artlyu was inclosed by Mr. Swan, showing the club before it was painted, and a rattle in his right hand, such as is used during the medicine dance. This club is very interesting and very highly prized. It is not intended for use as a seal club, but to be exhibited on ceremonial or state occasions, as an ensign of the rank of the family. It represents a dream of old Wikananish, which was so strongly impressed on his mind that he related it as an actual occurrence. It was believed by his family, and the legend has been handed down to the present day. The story was related by Benjamin, as follows:

"Wikananish was a great hunter of sea otter and seal; he could chase them into the deep water and there kill them with a blow of his clenched fist. He thus excited the anger of the *Sheeschee* a fabulous animal, half wolf and half fish. The head and forebody was wolf (*Chuchuhuioxl*), and the body and tail were the *Kowid*, or Killer, *Orca ater* (Cope). On one occasion, after he had been pursuing otters, he came ashore tired and lay down to sleep. He then dreamed that the *Sheeschee* chased him ashore, but he made his escape, and a panther, *Nani*, rushed on him, seizing both feet in his mouth, and throwing him on top of his head, where he was held by the fore paws of the animal. While in this position the *Sheeschee* came up and seized the *Nani* by the hind quarters. The Thunder bird (*Thlukloots*) then seized the *Sheeschee* by the tail with his beak and grasped with his powerful claws the fin and back of the Killer, and spreading his wings flew off with the whole party to the mountains, where Wikananish made his escape."

He told this dream so often that he came at last to believe it to be a reality. The snake in the mouth of the *Sheeschee* is emblematic of the *Hahaketoak*, or producer of lightning. This animal is also seen painted on each side of the bird's body. The face on the bird's tail indicates that it sees in all directions, and the sun on the bird's wings shows that it is the true bird of the sun, which is looked on by the coast tribes as the visible symbol of the Great Spirit. The swivel and three links of chain at the top of the handle of the club represent a piece of chain which old Wikananish procured from the vessel of the Spanish Commander Quadra, and showed them as a proof that he was a great chief. They were scoured bright, and during the presentation of gifts after a great banquet they were rattled each time a blanket was given to a guest. This specimen is the finest carving which has been seen here, done by an Indian south of Queen Charlotte Islands, and is valued at twenty blankets, although the writer procured it for as many dollars, as a mark of personal esteem.

TAYLOR, WM. J. Describes two New River mounds, in the ninth district of Berrien County, Georgia, on lot 275, 6 miles southwest of Nashville. They are on a dry sandy level near the edge of the hammock between a branch and a creek, 100 yards from the former and 300 from the latter. They were about 30 feet in base diameter and 4 feet high, and contained only ashes and charcoal.

THORN, H. T. Mentions two groups of mounds near Rollag, Clay County, Minnesota. One is half a mile northeast of Prairie Lake post-office, Bangor, Otter Tail County; the other a mile and a half southeast of Cormorant Lake, Becker County. There are two mounds in each group, but they have not been explored. On the authority of Mr. Ole Clousen, rock paintings are met with in Rock County.

TITCOMB, H. R. States that at the mouth of the South Platte Cañon, on the right bank of the river, at a distance of one hundred or more yards, is a large stone about 4½ by 5½ feet on the upper surface. This face is concave and slopes at an angle of 12° to 15° from the horizon. The surface is covered with figures cut deep in the rock, and a deep gutter incloses them and runs out at the lower edge and down 6 or 8 inches, where is a small hole, as though for the insertion of a peg to hang a vessel on. This neighborhood was at one time the camping ground of the Utes. The stone is in Acequia precinct, Douglas County, Colorado, on what is known as the Slocum ranch.

WHITNEY, J. L. Writing from Rose Hill, Ohio, speaks of copper axes and shell objects from a mound half a mile from Sharpsburg, Mercer County, Ohio. Ten pairs of shell relics were found resembling the bottoms of sandals. The mounds at this point are composed of sand and gravel. A large quantity of shell beads, a copper axe, and the skeleton of a tall man were recovered from the same mound. There are several mounds at this point composed of sand and gravel. The largest contains a quantity of very fine grayish-white sand, very hard, and streaked with bands of pure white sand.

WILLIAMSON, J. M. In opening shell mounds in Kentucky, found human bones showing the marks of teeth (human?), and many that had been split. Fragments of crania and jaw bones were seen mingled with images and perforated shells.

WILTHEIS, C. T., of Piqua, Ohio. Describes and figures an inscribed stone, a gneiss bowlder, with a granite vein through it, weight 13½ pounds. The inscription is very rude.

WOOD, Rev. PRESTON. The district lying north of Quincy, Ill., in the confluence of the Illinois and Mississippi rivers, abounds in traces of the Mound-Builders.

WOODMAN, H. T. Draws attention to a very curiously shaped earth mound, unlike any heretofore figured in that State, about 30 miles from Dubuque, Iowa. The mound will be figured and described.

WRIGHT, S. HART. Sends drawing and description of a work on Bluff Point, Yates County, New York, covering seven acres, and reticulated with graded ways.

REPORT OF A VISIT TO THE LURAY CAVERN, IN PAGE COUNTY, VIRGINIA, UNDER THE AUSPICES OF THE SMITHSONIAN INSTITUTION, JULY 13 AND 14, 1880.

During the summer of 1880 a party was sent out by the Smithsonian Institution to investigate the famous Luray Cavern in Page County, Virginia. An invitation had been extended by Messrs. Campbell and Stebbins, the proprietors of the cave, and Mr. Robert Garrett, vice-president of the Baltimore and Ohio Railroad, courteously granted passes over his road.

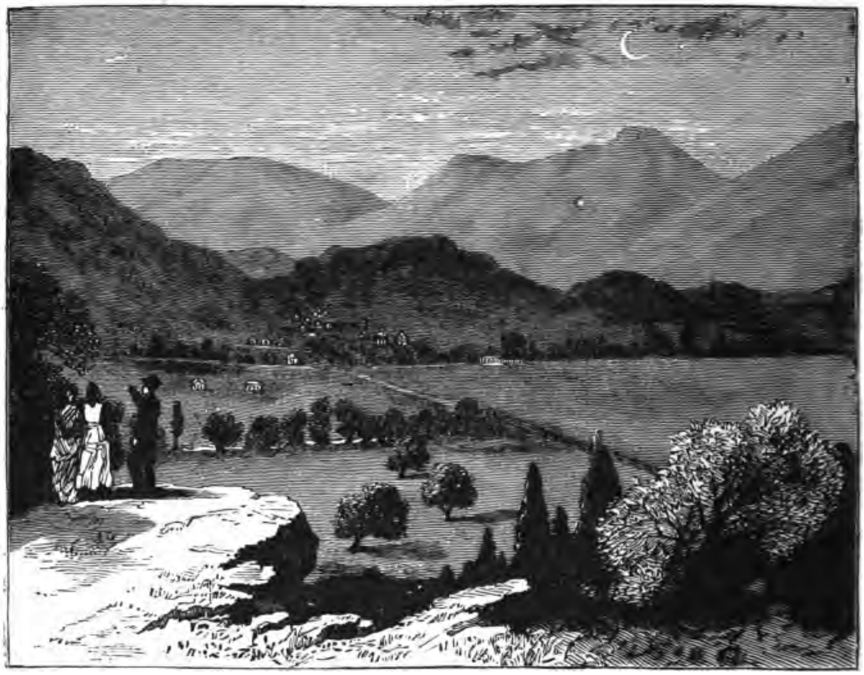
The party consisted of Wm. J. Rhees, chief clerk, Daniel Leech, corresponding clerk, Dr. Charles A. White, geologist, Prof. Charles Rau, archæologist, Prof. Otis T. Mason, ethnologist, Prof. Fred. W. Taylor, chemist, Dr. Elmer R. Reynolds, ethnologist, T. W. Smillie, photographer, and Prof. J. H. Gore, civil engineer.

Leaving Washington at 8.35 on the morning of July 12, the tourists, after passing Point of Rocks, Harper's Ferry, Charlestown, Winchester, Strasburg, and Woodstock, all made memorable in the late civil war, arrived at New Market at 2.44 p. m. Having selected quarters for the night, they made an excursion to the "Endless Caverns," about four miles south of the town. These caverns constitute, together, a series of very pretty grottoes, but no examination of them was allowed by the proprietors. Mr. Smillie, however, secured some very fine negatives of valley scenery.

After a night of refreshing sleep, the explorers were ready to mount Burke's tally-ho early the next morning for a most romantic ride over the Massanutton Mountain to Luray. Nothing could exceed for variety of quiet rural beauty the ever-changing landscape revealed in the great Shenandoah Valley at each turn of the winding ascent. There was plenty of time, as the stage lumbered along, to alight and walk leisurely behind in order to look back over the magnificent amphitheatre. Arrived at the crest, all were ordered to mount to their seats in order to "make time" down the tortuous eastern slope to the place of destination. A very picturesque ford of the east fork of the Shenandoah forms the gateway to the lovely Page Valley, having the Blue Ridge in the background.

Four miles of rolling limestone road brought the travelers to the quaint old town of Luray, straggling along the turnpike, and containing about 600 inhabitants. Those seeking a shorter route to the caverns may now go by rail directly to the spot over the recently-completed Shenandoah Valley Railroad. To select quarters for the night, to eat a sumptuous dinner, and to don their old clothes, occupied the party but a short time, and then all were ready to mount the tally-ho for the cave, which is situated on the north side of the turnpike about a mile west of the town. The entrance is near the summit of a rolling hill.

Before entering, the party listened to an interesting account of the search for the cavern by Mr. Stebbins, and, under the instruction of Professor White, observed carefully its topographical and geological environment.



The Blue Ridge and Town of Luray from Cave Hill.

For many years a small cave has been known in one of the hills near Luray, but it was not until August, 1878, that this wonderful freak of nature was discovered. This was due to the curiosity of Mr. B. P. Stebbins, a traveling photographer, who was convinced that the old cave was only a part of other similar formations. After diligent search, numerous diggings, and considerable expenditure of time and money, with no little ridicule from the villagers, he was rewarded by the brilliant discovery. Andrew J. Campbell, of Luray, was the first to enter the cave.

At this point Page Valley is several miles wide, and is bordered upon the east by the Blue Ridge, and upon the west by the Massanutton Mountain. The general surface is considerably diversified, and the rock stratum out of which the cavity has been excavated appears frequently on the surface throughout the neighborhood. The cave, therefore, is not in the side of a mountain, as most of the party had supposed, but at least four or five miles from the mountain ranges on either side. It has no obvious relation with them, except that its origin was partly coincident with their origin, and with the excavation of the valley by erosion. Indeed, it must be remembered that this gnawing away of material has produced not only the valleys, but the mountains themselves as they now exist, although they have such a considerable elevation above the lowlands.

The rocks throughout the whole of this region have been much displaced, having been flexed into great folds, the direction of which coincides with that of the Appalachian mountain range. In fact, these folds are a remnant of the results of that series of movements in which the whole system primarily originated.

The rock out of which Luray Cavern has been excavated is a compact, bluish limestone, not very evenly bedded, and weathering ruggedly on account of its heterogeneous texture. The few fossils discovered indicate that this limestone stratum is of Lower Silurian, probably belonging to the Trenton period.

The position of the cave in the middle of an open valley, distant from the mountains, and so much below their crests, shows that it was hollowed out toward the close of the epoch within which the formation of the valley took place. The character of the erosion leads to the conviction that the excavation was effected subsequently to the formation of the great folds referred to above. It is also plain that the foldings took place after the close of the Carboniferous period, because the strata of that period and those of later date are known to have been involved.

It is thus evident that the geological date of the origination of Luray Cave, although it is carved out of Silurian limestone, is considerably later than the close of the Carboniferous period. None of the facts yet ascertained warrant a more definite conclusion concerning the limits of the antiquity of the souterrain, and the most recent epoch at which it might have been formed is the Tertiary. It is highly probable that the date of its origination is not more ancient than that of the Mammoth Cave or the Wyandotte.

The history of its production is, of course, divided into two periods, namely, its excavation and ornamentation. The latter was wholly produced after, and perhaps long after, the chasm was finished. The cavity was wrought by the same agencies that produce all such effects in limestone formations, namely, by the erosion and by the dissolving action of water holding carbonic acid in solution, and coursing through previously formed fissures in the rocks. These cavities gradually become enlarged into chambers by the falling and removal of loose material to lower levels, and even through open outlets to the general drainage of the country.

The ornamentation of the cave, composed of lime carbonate, in the form of stalactite, stalagmite, calcareous tufa, travertine, cave pearls, calcite crystals, &c., has been produced by the precipitation of that mineral from solution in water, formerly percolating freely through the crevices of the rock which formed the ceiling, after the process of hollowing out was completed.

With these preliminary observations the party equipped themselves for their subterraneous journey each with a tin frame holding three lighted candles. The cold current of air around the mouth of the abyss warned them that their comfort would be enhanced by a heavy coat to enable them to sustain the shock of a sudden change in temperature from 96° to 56° Fahrenheit. The first descent is down a broad flight of square stone steps to a landing 50 feet below the surface. A short walk along a narrow passage leads to the vestibule, or entrance chamber, an irregularly shaped room 35 feet high and nearly 200 feet in diameter in the widest portion, the walls descending and contracting in an erratic and picturesque manner. As this was the first cave experience of most of the party, the unexpected magnitude of the chamber, the almost tangible darkness, the great variety of massive and curious forms, the ghastly shadows flitting about with their feeble candles, filled up the measure of expectancy. Indeed, had there been no rooms beyond far surpassing this one in every respect, all would have been perfectly satisfied. A very remarkable object in this chamber is Washington's Column, a monster pillar, nearly 25 feet in diameter, and very handsomely fluted.

A long, arched, irregular space beyond the vestibule, studded with fungoid and stalactites, has received the name of the Vegetable Garden, from the exquisite varieties of the incrustations. The botryoidal stalactites excited the admiration of the whole party. Wandering through this space, the explorers descended a well-built wooden staircase to Muddy Lake, passing across which over a wooden bridge, they were shown the Bear's Tracks, curious indentations on the tufaceous covering of a ledge, very strongly resembling the scratches made by an animal holding on by its claws. The next point of interest is the theater—a suggestive title from the resemblance to a great audience hall.

Ascending to the left the party came to the Fish Market. Here, on the side of a projecting wall, or series of escarpments, depend hundreds of sheet-like stalactites, mimicking most wonderfully rows of fish exposed for sale. Indeed, one has no difficulty about the identification of the species of bass, perch, shad, mackerel, &c.; some being gray all over, others having black backs and white bellies, and the illusion being perfected by a sufficient trickling to give a slimy, fishy appearance to the objects. All pronounced this to be the most curious, though not by any means the grandest and most impressive, object in the cavern.

From the Fish Market the path to the right leads to the Elfin Ramble, a low, open chamber, from 1 to 10 feet high, 600 feet long, and 300 feet

in breadth. Crossing the Ramble by
travertine floor and the cave clay, the
Chasm, a rift 500 feet long, 70 feet d
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party stood on the edge of Pluto's
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m sought to penetrate the darkness.
ctual fires to dissipate the gloom, but
locality of their possessors. Here is the
the cave. There is greater beauty, richer
r in many places, but no view stirs the sense of
that from the balustrade of Pluto's Chasm. Fol-
s down a long, rocky descent, which bears away to the
edge of the chasm, the party reached the bottom of this dark
From this point a fine view is obtained of the Specter, a tall
te stalagmite, looming up in the darkness in a very ghostly
This is a *cul de sac*, and it is necessary to retrace one's steps to

The Fish Market.

the Fish Market before making a new departure. Indeed, the a
ing fact was that the whole cavern occupies such a small area.
moth Cave one can walk more than ten continuous miles withc
on his tracks. At Luray the chambers branch off in most
entrance until one is entirely bewildered.
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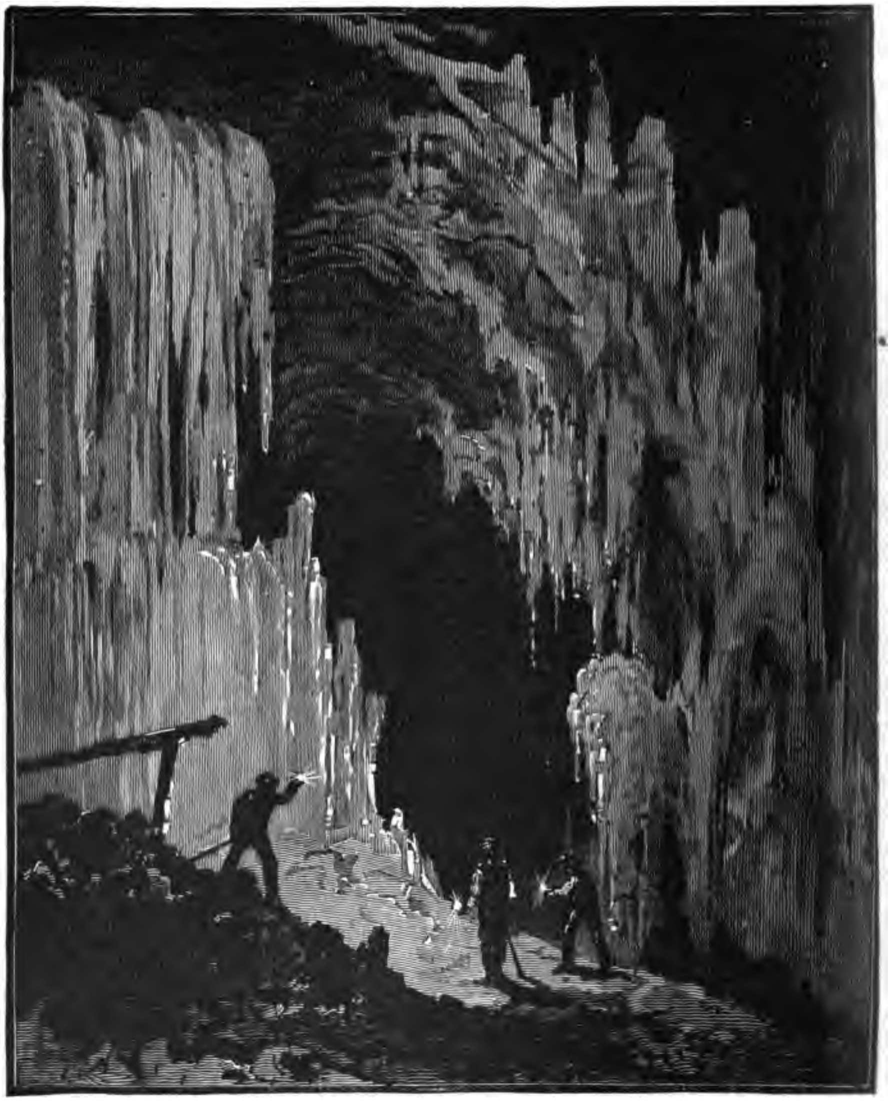
On the side of a rocky ledge by the path leading to the Fish Market is a miniature lake, in which the formation of calcite crystals is yet going on. It is a very beautiful object, the snow-white crystals forming a pleasing contrast with the brown color of the surrounding rock.



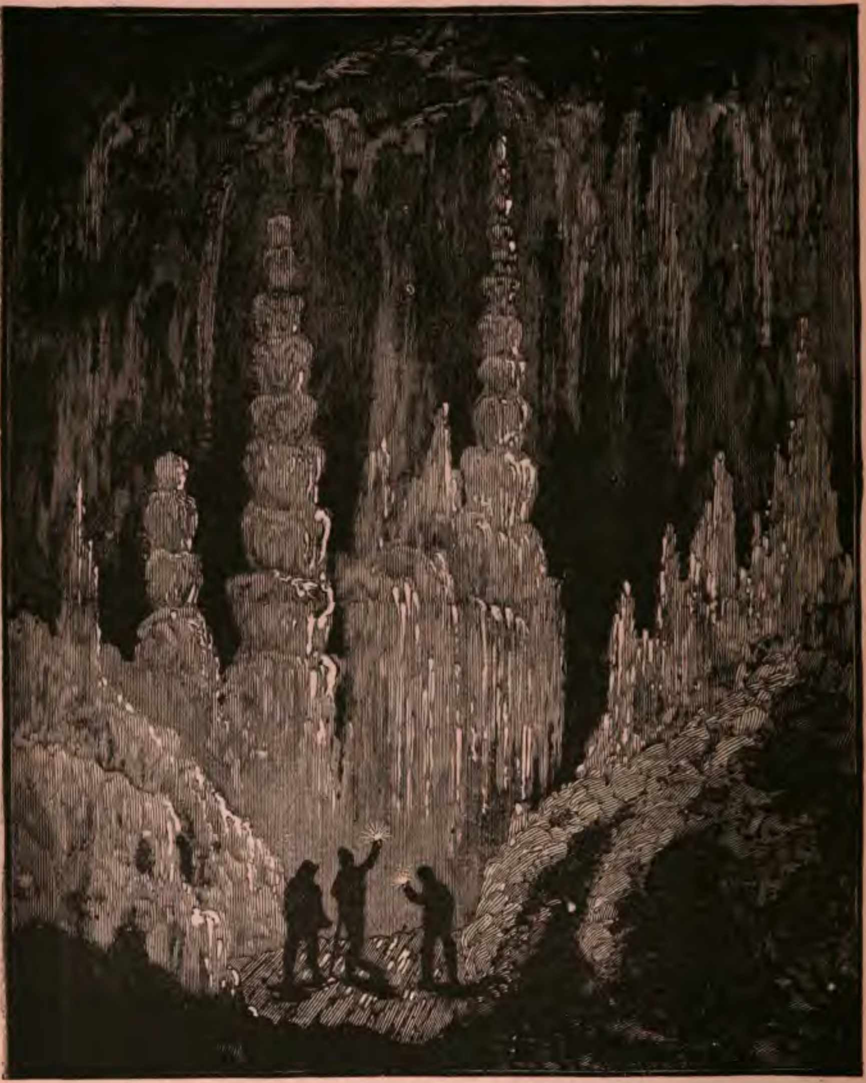
The Sentinel and Spectre.

The Grotto of Oberon is reached by crossing the Chasm. Here is a diminutive fountain surrounded by innumerable stalactites of great beauty. Just beyond lies the Bridal Chamber, so called on account of the delicately veiled stalactites and stalagmites occurring there. Until one d before these objects with romantic names, it occurs to him that cy of the narrator has quite as much to do with the matter as the lance of the objects. But all such doubt vanishes in the presence tions which call forth spontaneously from all beholders the same ex- tions. It was so in this chamber. The long, white, trailing masses baster suggested the same idea to all, and the absolute, starless t of shade on every side helped to complete the illusion. Just beyond Bridal Chamber is Giant Hall, where beauty gives place to wonder— e loveliness of Grecian finesse to the overpowering sense of Egyptian assiveness. Among the objects of special interest at this point are Titania's Veil and Diana's Bath, and, just beyond, the Saracen's Tent. The last-named object attracted a great deal of attention, and vividly recalled the pictures of crusading times, wherein the conical tent with its ample folds is decorated with the armorial devices of the occupant and surmounted by his banner.

The Saracen's Tent.

The next object of interest is the Cathedral, with its fantastic frescoe and stone organ. From the ceiling and walls depend thin sheets of stalactite of various lengths, which, upon being struck, give forth tones of great softness and effect. The impression made upon the party wandering through these dark abysses, when Mr. Campbell, without previous warning, played a familiar air, will hardly be forgotten.

There is nothing more beautiful in the cave than these scarfs, shawls, lambrequins—what shall we call them—of translucent calcite, some white as snow, others impregnated with the impurities of the soil above, falling in graceful folds, fringed with a thousand patterns, and so thin that a candle held behind one of them reveals all the structure within. With much regret the visitor sees the curtain fall upon this enchanted spot, but his sense of novelty is redoubled as he passes on to the Fallen Column, strangely misnamed. Once it hung from the lofty ceiling above, in company with many others, a ponderous mass over 50 feet long, at least 14 feet in its greatest diameter, and weighing about 400 tons. The entire



The Cathedral (Giant's Hall).

collection of these immense stalactites at this portion of the cavern resembles a great inverted forest of blasted trunks. The only spot in all the abyss where a sense of danger and utter helplessness seizes the explorer is when he stands beneath these magnificent stalactites, weighing over 500 tons each, held to the roof only by their own cohesion, and capable of falling, as evidenced by the prostrate giant before him. This feeling quickly subsides, however, when, upon closer inspection, he sees the fluted sides of the fallen one supporting long rows of secondary stalactites which indicate that perhaps centuries have elapsed since the crash of its downfall reverberated through these lonely halls. Drooping over the column to the right is the Angel's Wing, a formation of alabaster whiteness, nearly 10 feet high by 7 wide, and flecked all over with feather-like wrinkles. Truly one may be pardoned for giving his fancy loose rein, as he here beholds in this wing drooping over a fallen stalactite an emblem of the flight of centuries.

The Throne Room and the Throne, Chapman's Lake, the Tower of Babel, and Katie's Secret pass quickly in review as the path leads on to the Giants' Hall, the *chef d'œuvre* of this fairy underworld. On the verge of a towering cliff the beholder faces this chamber of wonders. Stretching away to the right is a seemingly interminable row of prodigious, glittering columns. They rise from out the depths of shade and are lost in the overhanging gloom. The magnesium light successfully combats these hosts of darkness and drives them into the alcoves and recesses above, beneath, and on either side, revealing forms of giant dimensions, weird outline, and infinite variety of ornament. Many feet below are the Chimes,—long sheeted stalactites, which on being vibrated give forth a deep, tremulous peal of varied tone.

The Empress Columns, the Sultana, the Double Columns, the Frozen Cascade, the Chalcedony Cascade, and the Hanging Rock being passed and admired, the scene opens into the Amphitheater, a large high-ceiled rotunda which has been tightly floored and fitted up with seats and chandeliers for a ball-room. Here on special occasions the citizens of Luray assemble to "chase the glowing hours with flying feet." Around the amphitheater are the Tombs of the Martyrs, Cinderella, and an endless number of robed and spangled heroes and heroines as yet unnamed. An ascent of two long flights of stairs leads from this rotunda to Campbell's Hall, an oblong chamber, about 200 feet in the long diameter and 50 feet high. The chief attraction of this room is the rich variety of coloring in the stalactites, including red, yellow, black, white, blue, gray, brown, with an infinite number of intermediate shades.

The returning path leads through the Bridal Chamber, where at least one couple sought their introduction into the mysteries of wedded love. Near at hand is the hollow column, a cylinder of great size, which rises from the floor and disappears through the ceiling as a stove-pipe. The column is hollow, as its name implies, a stream of water having worn away the center, through which, by means of a rope, an ascent can be made to a chamber nearly 60 feet above.

Passing onward the visitor stops for a few moments to admire what seems to be the retreating form of a lady in full party toilet. Her head is just hid by the jamb of the distant doorway; but rounded shoulders, delicate arms, shapely waist, and long, flowing skirt and train, profusely ornamented, all are there. The proprietors have named this the Ladies' Toilet, but some of the Smithsonian party suggested the title "Cinderella leaving the Ball." The path leads hence across Pluto's Chasm, by the Bridge of Sighs, to a rift bearing the grim title of Skeleton Gulch. Here, 110 feet below the mouth of the Chasm, in the bottom of a narrow trench, are the bones of what appears to have been a human being. The vandalism of former visitors made the proprietor rather shy of the exploring party; but as far as could be made out a man or woman lost in the cave had wandered to the edge of Pluto's Chasm, and, falling over, had here become entombed. Most of the bones are concealed by the tufaceous floor which has formed over them, but protruding through and above this are to be seen the head of a femur with an inch or two of the vertebral column, two or three small pointed projections resembling teeth, and a portion of a third bone undetermined. It was absolutely impossible to gain any information concerning these bones which would be of scientific value.

The Grand Gulch and Geyser.

The ground passed over is only one-fourth of the cave accessible, with but little trouble, to visitors; and yet the fleeting hours invite return and compel a speedy retreat.

It is a matter of profound regret that the peculiar combination of untoward circumstances precluded a more scientific examination of the Luray Cavern. It is quite certain that the work could be thoroughly done with little cost if the same party could have proper facilities another season. The daze of first impressions being off, there would be no hindrance to genuine work. An electric light should be used in place of the magnesium wire, and bearings, distances, and elevation carefully noted.

Comparing this great natural curiosity with others of the same class, it is safe to say that there is probably no other cave in the world more completely and profusely decorated with stalactitic and stalagmitic ornamentation than that at Luray. So abundant is this decoration that in only a small portion of the whole interior is unadorned rock visible. Here in this dark studio of nature are reproductions of all those objects which are wont to fill the mind with pleasure, wonder, or alarm—crystal fountains, spouting geysers, cascades, flower gardens, gems which are the crown jewels of nature set off against a background of velvet darkness, cathedrals gorgeously sculptured and frescoed, chimes and deep-toned organs, thrones, spectral beings, terrestrial, celestial, and infernal—objects whose multiplicity variety and splendor would exhaust the whole literature of mythic and fairy lore, in providing names for their infinite diversity of beauty. The indications are that the work was done with comparative rapidity, and the present dryness is sufficient evidence that the process has nearly ceased. Indeed, with the exception of a few spots where there is a slight percolation of water from above, and a few where the gathering into pools allows the crystallization of the salts of lime, the atmosphere is all too dry for the deposition of lime carbonate. The cessation of the production of stalactites after the chambers had received their finishing touches was doubtless due to a change of condition of the land in the neighborhood, causing the draining away into deeper channels of the surface water. This change probably resulted from the further deepening of the bed of the neighboring stream, after the greater part of the ornamentation had been completed. These circumstances indicate some degree of geological antiquity for the Luray Cavern. Hence a date as early as the Tertiary period has been suggested, but there is no apparent reason why it may not be supposed to have originated in one of the Mesozoic periods. In any case we may safely assume that the Luray Cavern long antedates the pristine man, although one of his descendants paid a fatal visit here long before Mr. Stebbins.

The obscurity of the aperture through which it was discovered by its present proprietors (1878) would naturally suggest that its existence could not have been previously known. The discovery of parts of a skeleton of man or of some large vertebrate, mostly embedded in tufaceous carbonate of lime, at the bottom of a chasm, shows that it was at one time of easier access; indeed, it is affirmed that former owners of the land had dumped loose rocks into the aperture to prevent young stock from wandering in and getting lost. The bones discovered are doubtless of considerable human antiquity; but, as they are found upon one of the few spots in the cave where the tufaceous material is still forming, it would appear probable that their age may not exceed two hundred or three hundred years.

A few insects have been found in Luray Cave, but a thorough examination with a view to collecting its fauna could not be made in the short stay allowed the Smithsonian party. No streams or pools of water have as yet been found in which an aqueous fauna might exist, and from present indications it is likely that the variety of animal life will prove to be very limited. At present a few spiders, flies, and one myriapod are known. An account of the former will appear in the *American Naturalist*, from the pen of the editor, Dr. A. S. Packard, jr. The myriapod has been described in volume iii, p. 524, of the Proceedings of the National Museum by Mr. J. A. Ryder and named *zygonopus whitei* in honor of Dr. C. A. White.

The vegetable growth is far more limited in extent. The proprietors have been compelled to form the walks and balustrades, through the cave, of green planks. In several places the white mold hangs from the under side of these planks in long graceful festoons, not unlike the moss upon the cypress trees of the South.

The party were greatly pleased with the courtesies received at the hands of the proprietors of the caverns, the citizen of Luray, and the Baltimore and Ohio Railroad Company, and only regret that their limited time and opportunities prevented their making a thorough scientific exploration.

The Institution is indebted to Mr. McDowell, treasurer of the Shenandoah Valley Railroad, for the use of the illustrations in this article.

DISCUSSION OF THE BAROMETRIC OBSERVATIONS OF PROF. E. S. SNELL (AMHERST COLLEGE).

BY PROF. F. H. LOUD, OF COLORADO COLLEGE.

The meteorological register of Amherst College was begun in 1835 by the late Prof. E. S. Snell, and consisted for the first year of a mere register of storms, to which daily observations of the thermometer and wind were added in 1836. Barometric observations were also begun in November, 1836, but the instrument employed for the first fifteen years was of inferior accuracy, and the observations were not corrected for capacity nor for temperature. With the beginning of the year 1852, new instruments by James Green—a barometer, thermometer, and psychrometer—were furnished by the Smithsonian Institution, and in 1854 the uniform hours of observation recommended by the Institution were introduced. The thermometer previously in use was at the same time tested and approved by Professor Guyot. From that time to the present the same instruments, with the exception of one bulb of the psychrometer, have been in use in the same positions; and, together with gauges for rain and snow, they comprise all the instruments used in the daily observations. From the same time the hours of observation have remained unchanged, viz, 7 a. m. and 2 and 9 p. m. The series of twenty-five years of observations, from 1854 to 1878, is therefore as nearly as possible homogeneous throughout, and it is scarcely less so in respect of the observers who have been engaged upon it, for few of the observations have been made by others than Professor Snell and one or two members of his family. His well-known scrupulous accuracy is therefore characteristic of the whole work. In 1858 five months of observation were made by the tutor in mathematics (now Rev. H. S. Kelsey, of New Haven) at his room in North College, the only instance of a removal of the instruments; but before the barometer observations made during this interval were incorporated with the others in the present reduction they were corrected for difference of level, no such correction having been made at the time.

Amherst is situated in latitude 42° 22′, longitude 72° 30′ W. The elevation of the barometer-cistern above the level of the sea was determined by Professor Guyot at 267 feet, and this computation has been verified by leveling from the track of the New London Northern Railroad, the height thus deduced being 266.5 feet. The readings of the barometer have never been corrected for elevation, but represent the actual pressure at Amherst in inches of mercury at 32° Fahr.

In regard to the fluctuation of atmospheric pressure, the observations at Amherst may probably be regarded as fairly representative of New England and the adjacent portion of New York. In confirmation of this opinion, the figures at the foot of this page are cited from a pamphlet of "Meteorological Researches for the use of the Coast Pilot," published in 1877 by the United States Coast Survey. They are the coefficients of Bessel's periodic function, under a modified form, in which ϵ_1 represents the value which φ, the time-angle, has at the maximum of the annual inequality, and ϵ_2 is the value of 2φ at the maximum of the semi-annual inequality. The coefficients B_0, B_1, B_2 are expressed in millimeters. The places named in the first column are all those within the above-named region which are embraced in the tables of the pamphlet (pp. 33, 34). The data from which the numbers in the first seven lines were computed were originally published in 1861 by the Smithsonian Institution ("Results of Meteorological Observations, 1854–'59"); those in the seven following lines were derived from the Reports of the Chief Signal Officer, 1872–1876. The latter are reduced to sea-level; the former are not. None of the fourteen are based upon more than six years' observations. The values given separately for Amherst, below the rest, are taken from the present reduction of the twenty-five-year series, and it will be seen that except in the value of ϵ_2 they agree well with the mean of all the others. This angle ϵ_2 appears from the given values to be very variable when a comparison is made of different places, or even of the same place in different short series of years, a circumstance, doubtless, connected with the fact that, as appears from the present reduction of the Amherst observations, the coefficient B_2 of the term $B_2 \cos (2\varphi - \epsilon_2)$ is less than that of the following term in 3φ,—of which term no account is made in the pamphlet.

Place.	B_0	B_1	B_2	ϵ_1	ϵ_2
	mm.	*mm.*	*mm.*	°	°
Steuben, Me	759.6	1.1	0.7	265	19
Gardiner, Me	757.0	1.2	0.5	290	350
Nantucket, Mass	761.6	1.0	0.6	289	40
New Bedford, Mass	759.5	1.1	0.7	277	51
Amherst, Mass	755.1	1.6	0.3	355	53
Burlington, Vt	751.9	1.1	0.6	261	30
Rochester, N. Y	746.7	0.9	0.6	354	51
Portland, Me	761.2	0.4	0.4	297	56
Boston, Mass	761.8	0.9	0.4	308	44
New London, Conn	762.5	1.0	0.3	323	63
Burlington, Vt	761.5	1.6	0.3	329	58
New York, N. Y	762.7	1.3	0.4	339	49
Oswego, N. Y	761.7	0.9	0.5	343	94
Rochester, N. Y	761.2	1.2	0.4	340	320
Mean of the above	....	1.1	0.5	312° 9′	39° 9′
Amherst, Mass	754.86	1.2	0.5	308° 57′	82° 20′

ANNUAL FLUCTUATION OF ATMOSPHERIC PRESSURE.

In order to deduce the annual march of atmospheric pressure with as much accuracy as the Amherst twenty-five-year series renders possible, the first step has been to derive the coefficients of Bessel's periodic function from the given monthly means. These, as given in the records, were of course originally derived from the daily means, and these last are simply the third part of the sum of the three daily observations, no additional weight being given to the evening observation. In the reduction of the barometric observations no correction for hours of observation has been attempted, but a correction for the unequal length of the calendar months was made in the manner presented by Mr. E. L. De Forest, and quoted on page 170 of Mr. Charles Schott's paper on temperature (*Smithson. Cont.*, vol. XXI). The monthly means thus corrected are as follows:[*]

January	29.7742	July	29.7065
February	29.7354	August	29.7257
March	29.6717	September	29.7968
April	29.6776	October	29.7500
May	29.6588	November	29.7071
June	29.6815	December	29.7626

The form of the function derived in this preliminary computation is the following:

$$P = 29.7207 + .0467 \sin(\theta + 142^\circ 20') + .0227 \sin(2\theta + 10^\circ 34') + .0241 \sin(3\theta + 44^\circ 41') + .0139 \sin(4\theta + 92^\circ 44').$$

From this formula a table of normal pressure for every day of the year was prepared, the value of P being computed directly from the formula for March 1st, and every tenth day thereafter to August 28th; also for September 1st and every tenth day to February 28th. The values for the intermediate days were then obtained by interpolation, using second differences, except a few days at critical epochs, the values for which were again computed from the formula. The table of normal pressures thus deduced is as follows, the integral part of each value in this and succeeding tables of barometric pressures being omitted for brevity, as it is in every case 29 inches. The computation was extended to four places of decimals, though it has been thought unnecessary to give more than three.

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[*] The amount of this correction for length of months may be seen by comparing the means here given with those appended to Table I in the line headed "Means from Record." I did not think it necessary to verify the work of Professor Snell in obtaining the means of the single months from the daily means or the latter from the observed heights, especially as the formula resulting from the present computation is used only to direct the subsequent work. A separate determination of the mean monthly pressures, independent of the recorded monthly means, occurs at the end of Table II. Since my work was completed, however, I have received from H. A. Hazen, M. A., a list of errors in the recorded monthly means which he has discovered in examining Professor Snell's work. Making allowance for these errors the mean monthly pressures, uncorrected for unequal lengths of the months, are as given in the last line of Table I, "Means from corrected record." In Table VI (the only remaining part of my work which is derived from the recorded monthly means) I have substituted Mr. Hazen's determinations wherever he has found those of Professor Snell erroneous.

TABLE I.

Atmospheric pressure for every day in the year—from the periodic function.

Day of the month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	785	756	698	677	668	671	693	711	767	785	720	723
2	786	753	697	676	663	671	693	712	769	783	719	725
3	786	751	696	676	662	672	694	713	771	782	717	727
4	787	749	695	675	662	673	694	714	772	781	715	729
5	787	746	693	675	662	674	695	716	774	779	714	732
6	787	744	692	674	662	675	695	717	776	777	712	734
7	788	742	691	674	661	676	695	719	777	776	712	736
8	788	739	690	673	661	676	696	720	779	774	710	738
9	788	737	689	673	661	677	696	722	780	772	709	741
10	787	735	689	672	661	678	697	723	782	770	709	743
11	787	732	688	672	661	679	697	725	783	768	708	745
12	787	730	687	671	661	680	697	727	784	766	707	748
13	786	728	686	671	661	681	698	728	785	763	707	750
14	785	726	686	670	662	682	698	730	786	761	707	752
15	784	724	685	670	662	682	699	732	787	759	707	755
16	784	721	684	669	662	683	699	734	788	756	707	757
17	783	719	684	669	662	684	700	736	769	754	707	759
18	781	717	683	668	663	685	700	738	789	752	707	761
19	780	715	682	668	663	685	701	740	790	749	708	764
20	779	713	682	667	663	686	701	742	790	747	708	766
21	777	711	681	667	664	687	702	744	790	744	709	768
22	776	710	681	666	664	687	702	746	790	742	710	770
23	774	708	680	666	665	688	703	748	790	740	711	772
24	772	706	680	666	665	689	704	750	790	737	712	774
25	770	705	680	665	666	690	704	752	789	735	713	775
26	768	703	679	665	667	690	705	754	789	733	715	777
27	766	701	679	664	667	691	706	756	788	730	716	778
28	764	700	678	664	668	691	707	759	788	728	218	780
29	762	699	678	664	669	692	708	761	787	726	720	781
30	760	......	677	663	669	692	709	763	786	724	721	783
31	758	....	677	......	670	......	710	765	......	722	......	784
Means	.7791	.7255	.6854	.6696	.6636	.6822	.6999	.7354	.7835	.7558	.7118	.7557
Means from record	.7740	.7365	.6732	.6780	.6588	.6806	.7057	.7250	.7968	.7506	.7068	.7624
	+57	−110	+122	−84	+48	+16	−58	+104	−133	+47	+50	−67
Means from corrected record	.7727	.7351	.6732	.6818	.6594	.6822	.6978	.7280	.7954	.7516	.7094	.7624

It here appears that the extremes of the annual fluctuation are the maximum 29.7902 on the day of the autumnal equinox, with the minimum 29.6612 on May 10, while a subordinate wave occurs in the beginning of the decline from the September maximum, reaching a minimum value of 29.7066 in the middle of November, with a subsequent rise to 29.7877 on the 8th of January.

The most marked deviation between the monthly means of the computed normal values and the means which were the basis of computation, aside from those which are due to maxima or minima already exposed, is found in the months of March and April; and this is due to a deviation from the regular progress occurring in the end of March, which will be noticed hereafter in its proper place.

It is well known that the accidental barometric oscillations have a greater range in the winter than in the summer months, and for the purpose of obtaining a quantitative determination of the normal degree of this atmospheric disturbance in every part of the year, as well as a more accurate account of the annual fluctuation of pressure, the *daily means* of the barometer for the twenty-five years were next arranged under each day of the year in two columns, one column containing those means which exceed the normal value for the particular day in question, derived from Table I, the other column containing the means for like-named days in the remaining years, all falling below the computed normal value. Each column having been added, the difference between its sum and the product of the normal value by the number of means in that column was found. Then if d and d' represent these differences, N the normal value, and n the number of means in both columns taken together, (twenty-five, except when an omission occurred,) $\frac{d+d'}{n}$ is the *mean of the departures of the daily means from the normal value* for that day of the year, and $N+\frac{d-d'}{n}$ equal to $\frac{1}{n}$th of the sum of the two columns, is the mean pressure for the same day. The mean pressures for every day of the year, thus deduced, are as follows:

TABLE II.

Atmospheric pressure for every day in the year—directly from observations.

Day of the month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	800	754	707	655	651	743	704	720	750	784	753	742
2	777	756	640	657	638	720	720	711	744	712	749	729
3	811	690	670	719	657	695	684	717	793	708	733	732
4	751	713	609	729	665	651	676	705	779	693	758	700
5	812	828	769	638	650	666	723	690	784	748	754	731
6	802	814	736	623	616	684	742	704	807	773	789	763
7	800	841	725	692	599	658	702	715	845	786	770	674
8	855	769	677	771	603	645	692	700	821	751	717	700
9	815	656	676	812	576	662	698	673	849	775	679	726
10	811	731	651	738	618	663	702	666	817	764	723	750
11	752	831	727	680	711	663	689	704	776	729	729	728
12	778	777	712	679	713	629	688	733	748	720	703	758
13	781	823	739	690	715	677	712	727	781	731	686	799
14	784	802	776	683	700	695	730	741	872	724	768	743
15	710	676	757	672	703	664	705	713	845	704	755	830
16	656	625	659	701	681	675	688	750	808	706	733	773
17	765	695	608	655	704	725	677	750	789	766	702	782
18	864	658	684	719	715	675	685	760	748	729	651	802
19	782	678	724	696	669	649	672	728	741	709	675	830
20	723	658	690	648	655	673	641	752	740	707	685	755
21	711	696	597	606	608	702	619	757	796	773	699	842
22	776	764	674	635	623	696	678	7[illegible]3	875	772	715	739
23	828	677	611	635	674	709	718	751	881	763	660	708
24	840	646	618	650	676	724	740	751	829	840	669	776
25	769	694	655	686	639	712	735	738	759	871	736	807
26	738	697	612	674	631	700	683	773	735	827	621	747
27	676	702	582	706	635	689	693	771	757	711	718	732
28	743	728	628	707	617	644	714	753	790	708	680	761
29	716	753	651	694	677	673	669	681	826	771	576	761
30	772	......	649	654	692	635	693	700	804	773	574	813
31	820	......	613	......	748	......	731	766	......	720	......	827
Sums	24.018	20.379 21.132	20.826	20.504	20.459	20.396	21.603	22.528	23.889	23.248	21.160	23.560
Means	.7748	.7280	.6718	.6835	.6600	.6799	.6970	.7267	.7963	.7499	.7053	.7600

As might be expected in so short a series as twenty-five years, the values embraced in this table are far from escaping the effect of accidental variations, but we may attempt to eliminate that effect by combining them in groups. The following are the mean values of atmospheric pressure in ten-thousandths of an inch, obtained directly from Table II, for thirty-six equal periods of 10.15 days each, beginning with January 0 and embracing the entire year. (The integral part, 29 inches, is omitted as before:)

TABLE III.

1	8030	19	7018
2	7584	20	6814
3	7606	21	7080
4	7600	22	6992
5	7247	23	7411
6	6964	24	7411
7	6931	25	7996
8	6917	26	7862
9	6276	27	8038
10	7060	28	7456
11	6736	29	7273
12	6685	30	7748
13	6385	31	7394
14	6798	32	7082
15	6714	33	6692
16	6711	34	7171
17	6774	35	7872
18	6886	36	7768

In this series few oscillations appear beyond the two principal ones already noted. Beginning with the yearly minimum on May 10th, which falls in the thirteenth period, the rise to the September maximum, in the twenty-seventh, appears to be broken by a depression culminating in the twentieth period (about July 17), and in like manner the fall thence to the November minimum is checked by a subordinate maximum in the end of October, the thirtieth period. The only remaining noteworthy departure from the normal value is more marked than either of the preceding, and consists of a depression in the ninth period—the ten days following the vernal equinox—which appears to amount to a true equinoctial storm. Thus each of the two equinoxes is a definite barometric epoch, though they are marked by opposite characteristics.

A tendency is apparent in one or both of the periods adjacent to a maximum or minimum to depart from the normal values in an opposite direction, so that the gradual approach to the critical value, on the part of the more distant periods, appears to culminate ten or fifteen days from the true epoch, and a *double* maximum or minimum is the result. Examples may be noticed in the fourteenth period, immediately following the yearly minimum in May, while a double maximum occurs in September; also, in the case of minor oscillations, the minima in March and July are each followed by a single period of high barometer, and the January maximum is both preceded and followed by single periods slightly lower than those adjacent to them. The phenomenon appears suspicious, as though due to accidental variations, yet some ground for a contrary opinion may be derived by examining the deviation of each period from the normal pressure.

As will presently be shown, the probable error of one of the values in Table III is a variable quantity, having for its mean value 0.0095, while at its maximum it is about 0.0122 and at its minimum 0.0058. If now we compute a value for the middle day of each period from the periodic function, in the same way as Table I, but to four places (which may be regarded as representing accurately enough for the present purpose the normal value of pressure for the period, aside from the irregularities now under discussion), these normal values, subtracted from the successive values of Tables III, will leave the following residuals:

1	+ .0158
2	— .0260
3	— .0096
4	+ .0131
5	+ .0012
6	— .0081
7	+ .0018
8	+ .0081
9	— .0510
10	+ .0317
11	+ .0041
12	+ .0040
13	— .0229
14	+ .0178
15	+ .0043
16	— .0038
17	— .0055
18	— .0015
19	+ .0065
20	— .0183
21	+ .0020
22	— .0180
23	+ .0072
24	— .0104
25	+ .0255
26	— .0015
27	+ .0048
28	— .0318
29	— .0291
30	+ .0421
31	+ .0253
32	+ .0016
33	— .0148
34	— .0159
35	+ .0310
36	— .0002

It here appears that the periods following the March and May minima and the January maximum deviate from the normal value in the opposite direction from the adjacent critical value, and to an amount exceeding the estimated probable error for the time of year, while the periods preceding the January and September maxima appear to be normal, the double maximum in these cases being produced by a relatively high value of the period in which the anticipatory subordinate maximum occurs, rather than by a relatively low value in the period separating it from the true maximum. The effect of the disturbance in March–April appears to be confined to the ninth and tenth periods, and it produces that divergence of the computed and observed means for the two months, previously noticed in connection with Table I.

The division of the year into thirty-six equal periods, in Table III, gives the opportunity for a recomputation of Bessell's periodic function. The following are the coefficients of ten terms, based upon the thirty-six periodic means. The first five or six terms may be regarded as replacing by more accurate values the formula previously derived, and from which Table I was computed; the concluding terms are, perhaps, chiefly interesting as showing the impracticability of obtaining actual convergence from a series of observations no longer than the present:

$B_0 = 29.7194$

$B_1 = 0.0480$ $B_4 = .0128$ $B_7 = .0135$

$B_2 = .0210$ $B_5 = .0028$ $B_8 = .0059$

$B_3 = .0271$ $B_6 = .0090$ $B_9 = .0115$

The corresponding angles are as follows:

$\beta_1 = 141^\circ\ 3'$ $\beta_4 = 89^\circ\ 56'$ $\beta_7 = 139^\circ\ 0'$

$\beta_2 = 7\ \ 40$ $\beta_5 = 5\ \ 8$ $\beta_8 = 186\ \ 12$

$\beta_3 = 45\ \ 50$ $\beta_6 = 104\ \ 26$ $\beta_9 = 242\ \ 30.$

Mr. E. L. De Forest, in the *Analyst* for July, 1877, refers to a previous paper of his own in which he has pointed out a simple test of the accuracy of the adjustment of a series of values subject to accidental variation. The test quoted is in substance as follows: If the original (observed) values be subtracted from the adjusted values, term by term, the result is the series of residual errors. If the terms of this series be pointed off into groups, by inserting a point of division at every change of sign, the most probable number of terms occurring in groups of three or more is $\frac{1}{2}N \pm .533\sqrt{N}$; where N denotes the whole number of terms of the series, and the expression following the sign ± is the probable error. If the number of terms occurring in such groups falls short of $\frac{1}{2}N$ by more than the probable error, the inference is that the inequalities of the series have not been smoothed out enough; but if it exceed $\frac{1}{2}N$ by more than the probable error, the series has been smoothed too much. From the nature of the periodic function, the adjustment effected by it would be expected to err (if at all) in the latter of these two directions. In fact, when a series of residuals is formed by subtracting the terms of Table II successively from the corresponding terms of Table I, the number of terms or signs occurring in groups of three or more exceeds half the whole number of terms by 79, while the probable error, $.533\sqrt{366}$, is only 10.3. Though a closer approximation to a perfect adjustment might probably be derived by the use of the more exact coefficients just obtained, it seems preferable, for the purposes of comparison, to use a different process of adjustment, and hence the method of successive means has been employed. The arithmetical means between each term of the series of Table II and the next succeeding term form the first order of means, the second is derived in the same way from the first, and so on until the tenth order of means is obtained, which constitutes Table IV.

TABLE IV.

Computed normal pressure for every day in the year.

[Tenth order of means from Table II.]

Day of the month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	799+	760	697	656	658	719	683	714	750	765	746	679
2	795	748+	681	671	653	710	692	713+	762	742+	745+	704
3	791	745	675	681	651	695	697	710	773	728+	749	718
4	791	758	685	682	647	680+	702+	706	784	729	754	723
5	796	778+	701	678	638	671	708	703+	796	741	759	723
6	805	791+	711	684	624	666	711	702	809	755	757+	720
7	813	785	708	706	612	662+	708+	699	820	764	747	716
8	816	766	696+	731	608+	659+	703	694	825	765	732	716+
9	811	753	689	741+	619	658	699	690+	820	760+	719	723+
10	799	756+	691	732	642	658	697	693	807+	751+	714	734+
11	786	772	704	713	670+	658	697+	703	795+	741	713	747
12	776	784	720+	695+	692+	661	701	715	793	732	716+	759
13	765	777	732+	686+	702	667	705	725	803+	725	723	770
14	751	751	731+	683	703	674	706	731	816	721	731	779+
15	740	716	715	683	700	680	702	735	818+	720+	731	786
16	742	687+	693	684	697+	684	694	740	807	724	720	790
17	757	673	677+	685	694	684	684	745	787	727	703	793
18	770+	671	674+	682	686	681	674	746+	770	728+	688+	796+
19	770	675	674	672	671	678+	664+	746+	766	730	684	797
20	762+	684+	667	656	655	681	659	746	778+	738	685	791
21	762+	694	654	643	645	689+	663+	745+	803	752+	689	780
22	775	697	641	638+	644	699	679+	745+	824+	772+	689	768
23	788+	693	633	644	649	706	699	746+	829+	794	687	761
24	788	688	628	656+	651	708+	712	749	814	810	684+	761
25	772	689	624	670+	647	705	713	753	790	810+	682	763
26	748	697	620	683	641+	695	707	754	774+	793	677+	761
27	732+	708	619+	690	642	682	700	749	774	769	667	759+
28	732	715	624+	689	652	672	696	738	784	753	652	765
29	744	711	632	681	672	668+	697	729	790	748	645	778
30	758	......	638	669	696	674	702+	728+	784	748	655	792
31	765	......	645	......	714	......	709	737	......	747+	......	800

On applying the test of Mr. De Forest to this series the total number of signs occuring in groups of three or more is found to be less than half the whole number of terms by 18—a difference much less than that of Table I, though nearly double the probable difference of a perfect adjustment.

In respect to the treatment of the 29th of February, this table is less accurate than the others; for the pressure for that date, as derived from Table II, should in strictness have been allowed only one-fourth of the weight of the other values; but as such a discrimination could not conveniently be made in the computation, the 29th was treated precisely like the adjacent dates. In all the other tables due allowance is made for the peculiarity of that date.

The sign + appended to numbers in Table IV indicates a fraction between $\frac{40}{102}$ and $\frac{60}{102}$. Smaller fractions are disregarded, and for larger ones the third figure is increased by 1.

MEAN DEPARTURE FROM NORMAL VALUE, AND PROBABLE ERROR.

In describing the method of deriving the numbers which constitute Table II it was shown that for each day of the year, along with the mean pressure, another number was deduced, which was called "the mean of the departures of the daily means from the normal value." The series of the mean departures thus obtained is as follows, in thousands of an inch of mercury:

TABLE V.

Means of the Departures of Daily Means from Normal Value.

Day of the month.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	235	219	214	294	171	168	110	118	155	225	178	235
2	232	253	251	224	179	137	111	162	140	163	186	216
3	214	268	180	178	191	129	093	118	124	198	189	232
4	174	296	187	231	151	133	126	122	139	211	219	266
5	190	257	205	222	133	150	094	138	112	161	196	199
6	225	195	234	202	142	124	101	134	106	166	239	231
7	234	236	173	175	152	146	102	105	134	171	281	256
8	291	249	223	169	179	150	106	127	173	186	237	216
9	222	260	208	171	145	173	143	152	131	163	155	271
10	342	197	195	159	131	144	105	131	126	167	184	239
11	184	209	197	135	137	169	094	103	127	126	180	145
12	183	229	167	172	151	168	095	081	159	173	206	224
13	239	143	207	190	150	133	104	087	170	175	215	250
14	240	179	161	230	188	131	112	075	162	181	179	218
15	233	201	166	166	185	135	100	084	118	203	236	215
16	192	265	251	226	154	120	117	115	156	211	303	190
17	227	263	224	197	132	117	107	115	137	140	281	242
18	223	237	167	163	135	112	122	114	152	162	235	257
19	255	190	234	185	148	108	121	112	170	172	218	244
20	171	196	157	162	156	123	110	131	113	196	224	237
21	246	223	260	177	156	106	125	131	133	172	205	270
22	239	197	211	152	159	107	148	127	139	161	235	251
23	229	234	221	176	112	109	111	130	173	239	243	238
24	255	251	249	186	134	099	084	100	169	225	203	233
25	240	296	247	177	116	121	093	135	130	249	237	195
26	242	183	203	190	126	113	099	114	115	207	226	170
27	197	213	166	136	164	107	092	135	154	227	171	213
28	186	248	209	161	175	114	068	125	123	247	171	225
29	190	192	226	172	120	122	096	131	165	212	229	215
30	270	......	233	180	127	126	089	135	190	246	283	222
31	178	......	250	......	173	......	110	126	......	179	......	225
Sums	6.978	{6.387 {6.579	6.476	5.558	4.672	3.894	3.288	3.713	4.295	5.914	6.544	7.040
Means	.2251	.2278	.2089	.1853	.1507	.1298	.1061	.1198	.1432	.1908	.2181	.2271

An inspection of this table shows a marked annual variation. To exhibit its law, the monthly means at the foot of the table were first corrected for the unequal length of the months, and then used to compute coefficients for Bessel's periodic function. The resulting formula is the following:

$$D=0.1775+.0607\sin(\theta+76^\circ.1)+.0094\sin(2\theta+218^\circ.0)$$
$$+.0036\sin(3\theta+275^\circ.6)+.0016\sin(4\theta+259^\circ.6.)$$

The coefficients of the five terms here given exhibit a more satisfactory convergence than any five successive terms in the formula for the annual fluctuation of pressure, and indicate that the function in question—the amount of atmospheric disturbance—is entitled to consideration as a meteorological element governed by a simple law of change. By differentiating the formula the function is found to have two nearly equal maxima on December 11 and February 4, of which the latter is the higher, their respective values being 0.2261 and 0.2275. Between these points the curve maintains a nearly uniform height, having its minimum on January 1, when the value is 0.2254. The minimum for the year is 0.1089 on July 23.

Besides its significance as an independent meteorological element, the function may also be regarded in its relation to the probable error of the numbers composing Tables II, III, and IV. Referring to the method by which the mean departures were computed it will be seen that as the number of daily means in excess of normal value varies but little from the number in defect, the inaccuracy of the normal value of pressure as derived from Table I must be too slight to affect appreciably the resulting formula for mean departure; hence this mean departure may be regarded as identical with the *mean of the errors* of single daily means, regarded as measurements of the true normal pressure. The "mean error" will then be found by multiplying the mean departure by the constant 1.2533, or the probable error by multiplying it by 0.8453. Applying the latter factor to the extreme and mean values of the function it appears that the probable error of a single daily mean is ±0.1923 on February 4, ±0.09205 on July 23, and has a mean value of ±0.1500. If no daily means had been omitted in the records each of the numbers in Table II would have been derived from twenty-five daily means, and its probable error would have been one-fifth that of the daily mean. But in fact 184 of the 9,131 daily means are wanting, so that the average number of means in a column is 24.496. Hence the factor by which the probable error of a daily mean is to be multiplied is $\frac{1}{\sqrt{24.496}}$ or 0.202. The products, .0388, .0186, and .0303, are the extreme and mean values of the probable error of the numbers in Table II. Each of the numbers in Table III is the mean of 10.15 numbers of Table II, hence the probable errors of the values in Table III are: Maximum, .0122; minimum, .0058; mean, .00951.

Finally, Table IV is derived from Table II by taking the tenth order of means. Now, if from the series of terms T_1, T_2, T_3, etc., m successive orders of means be derived (m being an even number), the value of that term in the mth order which corresponds to Tn is:

$$\frac{1}{2^m}\left\{ T_{(n-\frac{1}{2}m)} + m\,T_{(n-\frac{1}{2}m+1)} + \frac{m(m-1)}{2}\,T_{(n-\frac{1}{2}m+2)} + \cdots\cdots \right.$$
$$\left. \cdots\cdots + m\,T_{(n+\frac{1}{2}m-1)} + T_{(n+\frac{1}{2}m)} \right\};$$

the coefficients being those of the mth power of a binomial.

Hence, supposing the probable error of each term of the original series to be r, the probable error R of a term of the mth order will be:

$$R=\frac{r}{2^m}\left\{ 1+m^2+\frac{m^2(m-1)^2}{2^2}+\cdots\cdots+m^2+1 \right\}^{\frac{1}{2}}.$$

If 10 be put for m in this formula, we have

$$R=0.4198r.$$

Hence the probable errors of the values in Table IV are the following: maximum, February 4, 0.0163; minimum, July 23, .0078; mean, .01272.

It is to be observed that in all the above determinations of probable error, the maximum and minimum values of the error, being derived from Bessel's function, are probably somewhat incorrect by not departing widely enough from the mean value, but the mean value itself is not liable to such an error.

The probable error of the mean annual pressure, 29.7194, is ±0.00159; that of the mean of a single year is ±0.00785.

BAROMETRIC RANGE.

Of the readings of the barometer at each of the regular tri-daily observations during a month, corrected for temperature, the highest and lowest values are noted in the register at the end of the month, and the difference between them is recorded as the barometric range for the month. The means of these ranges for like-named months in the twenty-five years are the following: January, 1.255; February, 1.301; March, 1.186; April, 1.012; May, 0.875; June, 0.727; July, 0.615; August, 0.655; September, 0.846; October, 1.042; November, 1.221; December, 1.427.

It will be noticed that the annual fluctuation of barometic range copies closely that of the mean departure of the daily mean. The minimum in July, the double maximum in December and February, with the intervening value for January, which, though lower than that of either of the adjacent months, is higher than that of any of the remaining nine; all these peculiarities are common to the two functions. They differ, however, in the relative height of the two maxima, the December maximum being in this case higher than that in February.

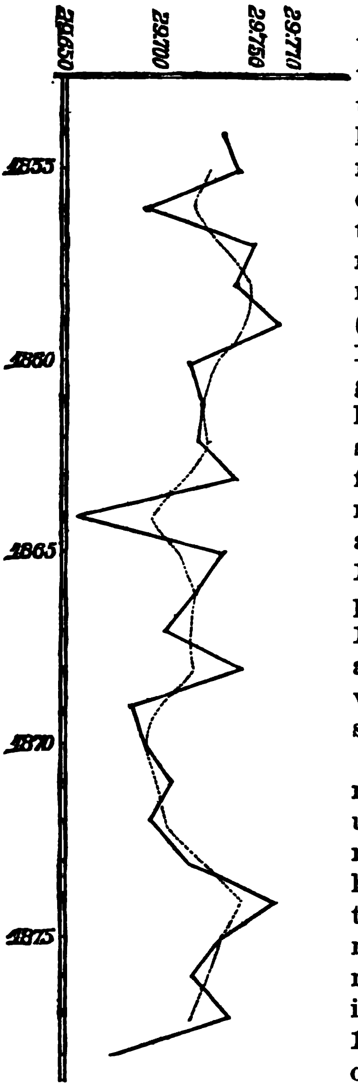
SECULAR VARIATIONS OF ATMOSPHERIC PRESSURE AND DISTURBANCE.

Among the variations of meteorological elements supposed to have a period of more than a year, two are embraced within the subject of the present discussion, viz, that of atmospheric pressure, and that of atmospheric disturbance, expressed by barometric range.

TABLE VI.

Variation of the annual means of pressure.

Year.	Mean pressure.	Adjusted mean.	Sun-spot number.	Remarks.	Year.	Mean pressure.	Adjusted mean.	Sun-spot number.	Remarks.
1854	29.734	....	19.2		1867	29.706	29.719	8.0	S. s. min.
1855	.741	29.727	6.9		1868	.744	.720	40.2	
1856	.695	.720	4.2	Bar. min.; s. s. min.	1869	.687	.703	84.1	
1857	.749	.733	21.6		1870	.694	.696	139.6	Bar. min.; s. s. max.
1858	.741	.748	50.9	Bar. max.	1871	.708	.702	109.6	
1859	.762	.745	96.4		1872	.697	.705	101.7	
1860	.717	.730	98.6	S. s. max.	1873	.718	.723	66.3	
1861	.723	.721	77.4		1874	.760	.743	44.6	Bar. max.
1862	.721	.726	59.4		1875	.735	.737	17.1	
1863	.740	.715	44.4		1876	.720	.728	11.3	
1864	.658	.698	47.1	Bar. min.	1877	.737	.718	12.3	
1865	.734	.712	32.5		1878	.678	....	3.4	
1866	.720	.720	17.5	(Bar. max.)					



In Table VI the first column contains the names of the several years, from 1854 to 1878, inclusive; the second column shows the annual means of pressure, taken directly from the register. In order to eliminate minor and irregular variations, the second order of means of this series is taken, and this constitutes the third column. The remaining column contains Wolf's sun-spot numbers, as given by Professor Loomis. (*Am. Journal of Science and Art*, April, 1873, p. 247.) As the numbers are there given only through 1871, Professor Loomis has kindly furnished me with those for the subsequent years. The table indicates a fluctuation of annual pressure, having a range considerably in excess of the probable error of a yearly mean. The years 1856, 1864, and 1870 are those of minimum pressure, while maxima fall on the years 1858, 1866, and 1874. Hence the period appears to consist of about eight years, with no manifest relation to that of the sun-spots. (See adjoining diagram.)

Table VII shows the fluctuation of barometric annual range. As the range of pressure attains its greatest extent each year during the winter months, the annual range here considered is the difference between the highest corrected reading of the barometer in any one winter and the lowest reading for the same winter; *i. e.*, the year in which each range is taken begins July 1 and ends June 30. The second column of the table contains the names of the months in which these highest and lowest readings occurred, the month of the maximum being named first in each case. The two columns following contain the extreme values of pressure, and the next column (the fifth) contains the range or difference between them. The periodic fluctuation of the numbers in this column is so marked as to admit of taking four orders of means, by which the accidental variations are eliminated. The result of this process constitutes the sixth column. The seventh and last column contains the series of sun-spot numbers; but as the year to which any sun-spot number, as given by Wolf, belongs has its beginning and end at January 0, instead of July 0, the sun-spot numbers for this column are obtained by taking the first order of means of Wolf's series (that is, the mean of Wolf's numbers for 1836 and 1837 is taken as the sun-spot number for the year 1836–'37, the mean of the given numbers for 1837 and 1838 as the number for 1837–'38, etc.). In this comparison the observations for the years 1836 to 1853, hitherto omitted from this discussion, are included; for though in respect to the absolute values of pressure these observations are not comparable with the later ones, they may be considered as fairly comparable as far as range is concerned, though less accurate.

TABLE VII.

Variation of the Annual Barometric Range.

Year.	Months of extremes.	Yearly maximum.	Yearly minimum.	Yearly range.	Mean range.	Sun-spot number.
1836–'37	....	30.38	28.50	1.88	....	103.8
1837–'38	....	30.32	28.61	1.71	....	96.8
1838–'39	....	30.69	29.00	1.69	1.78	75.5
1839–'40	....	30.40	28.40	2.00	1.79	60.1
1840–'41	....	30.42	28.77	1.65	1.74	40.7
1841–'42	....	30.41	28.75	1.66	1.70	24.6
1842–'43	....	30.48	28.80	1.68	1.75	14.0
1843–'44	Apr.–Jan.	30.58	28.61	1.97	1.80	*10.8
1844–'45	Oct.–Dec.	30.34	28.60	1.74	1.79	23.0
1845–'46	Dec.–Oct.	30.54	28.90	1.64	1.79	40.0
1846–'47	Oct.–Mar.	30.48	28.40	2.08	1.77	63.2
1847–'48	Oct.–Feb.	30.42	28.88	1.54	1.64	89.9
1848–'49	Feb.–Apr.	30.45	29.10	1.35	1.54	†98.0
1849–'50	Feb.–Feb. Mar.	30.50	28.90	1.60	1.63	80.0
1850–'51	Feb.–Dec.	30.58	28.64	1.94	1.78	63.2
1851–'52	Feb.–Apr.	30.423	28.605	1 818	1.83	57.0
1852–'53	Dec.–Jan.	30.486	28.546	1.830	1.801	45.0
1853–'54	Nov.–Dec.	30.463	28.799	1.664	1.796	28.4
1854–'55	Jan.–Dec.	30.664	28.695	1.969	1.823	13.0
1855–'56	Dec.–Dec.	30.381	28.640	1.741	1.835	*5.5
1856–'57	Feb.–Dec.	30.687	28.773	1.914	1.809	12.9
1857–'58	Jan.–Oct.	30.569	28.846	1.723	1.733	36.2
1858–'59	Dec.–Mar.	30.446	28.817	1.629	1.634	73.6
1859–'60	Dec.–Feb.	30.427	28.948	1.479	1.591	†97.5
1860–'61	Jan.–Feb.	30.431	28.787	1.644	1.640	88.0
1861–'62	Jan.–Feb.	30.549	28.779	1.770	1.698	68.4
1862–'63	Feb.–Apr.	30.718	28.970	1.748	1.670	51.9
1863–'64	Dec.–Feb.	30.419	28.919	1.500	1.646	45.7
1864–'65	Dec.–Dec.	30.340	28.703	1.637	1.734	39.8
1865–'66	Jan.–Apr.	30.672	28.637	2.035	1.887	25.0
1866–'67	Feb.–Dec.	30.584	28.543	2.041	1.924	*12.7
1867–'68	Feb.–Apr.	30.526	28.755	1.771	1.819	24.1
1868–'69	Oct.–Dec.	30.363	28.681	1.682	1.688	62.1
1869–'70	Jan.–Jan.	30.380	28.820	1.560	1.586	111.8
1870–'71	Jan.–Feb.	30.428	28.869	1.559	1.510	†124.6
1871–'72	Dec.–Feb.	30.323	29.036	1.287	1.527	105.6
1872–'73	Jan.–Mar.	30.387	28.645	1.742	1.656	84.0
1873–'74	Feb.–Nov.	30.453	28.509	1.944	1.762	55.5
1874–'75	Dec.–Nov.	30.372	28.807	1.565	1.777	30.8
1875–'76	Feb.–Feb.	30.629	28.621	2.008	1.740	14.2
1876–'77	Dec.–Dec.	30.320	28.824	1.496	1.677	11.8
1877–'78	Jan.–Mar.	30.374	28.764	1.610	....	7.9
1878–'79	Feb.–Dec.	30.458	28.641	1.817	....	....

In this table a relation between the mean range and the sun-spot numbers is obvious at a glance, not a single maximum or minimum of the latter series failing to fall on the same year with an opposite phase of the fluctuation of mean range. But there is an additional peculiarity of this fluctuation which appears to have nothing in common with that of the solar spots except equality of period.

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* Years of minimum sun-spots, and maximum barometric range.

† Years of maximum sun-spots, and minimum barometric range.

From each year of minimum sun-spots and maximum range to the year of the opposite phases the progress is always uninterrupted, but the rise of mean range from the latter point to its next maximum on the year of the sun-spot minimum is checked in every instance nearly midway, or when the sun-spot number is about 40, by a decline lasting in each of the four cases through two years, after which the increase of range is resumed.

The highest corrected barometer-reading since 1853 is 30.687 on February 12, 1857, and the lowest is 28.509 on November 18, 1873. Their difference, the range in twenty-five years, is 2.178 inches.

Of the appended diagrams, the first (divided into five sections, and marked Parts 1 to 5, forming continuous curves for the year) shows the barometric pressure for each day of the year, as given numerically in Tables I, II, and IV. The full (or solid) line exhibits the daily values of pressure directly from observations (Table II), while the fine dotted curve shows the normal values computed from the periodic function (Table I), and the intermediate broken (or coarse dotted) curve is taken from the values given in Table IV. Vertical lines are inserted at intervals, having the middle of their length placed at the height of the annual mean (29.719), and showing by their extent upward and downward the probable error of Table II for the date. The probable error of Table IV is also indicated by corresponding marks upon the vertical lines.

Probable errors of Tables II and IV, for each month.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Table II	.038	.0385	.035	.031	.0255	.022	.018	.020	.024	.032	.037	.038
Table IV	.016	.016	.015	.013	.011	.009	.0075	.0085	.012	.0135	.0155	.016

The concluding diagram exhibits graphically the connection between the fluctuations of barometric range and of sun-spot amount, as given in Table VII.

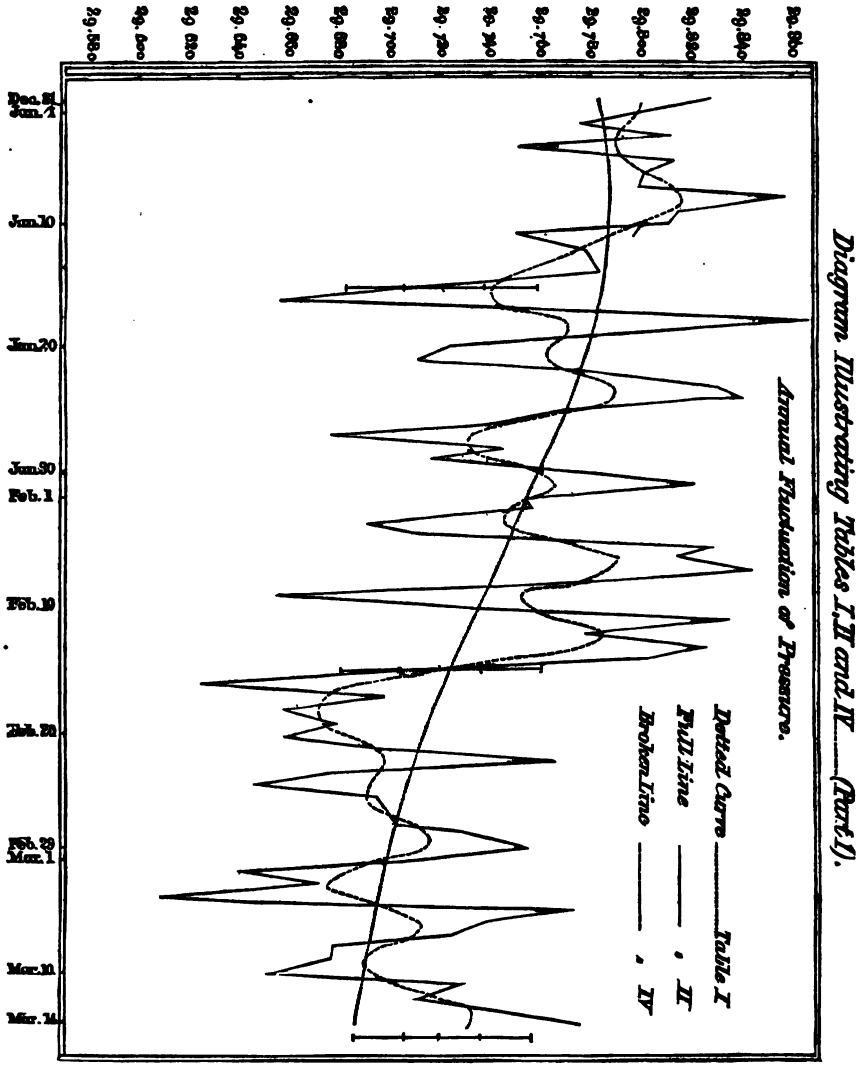


Diagram Illustrating Tables I, II and IV.—(Part I).

Annual Fluctuation of Pressure.

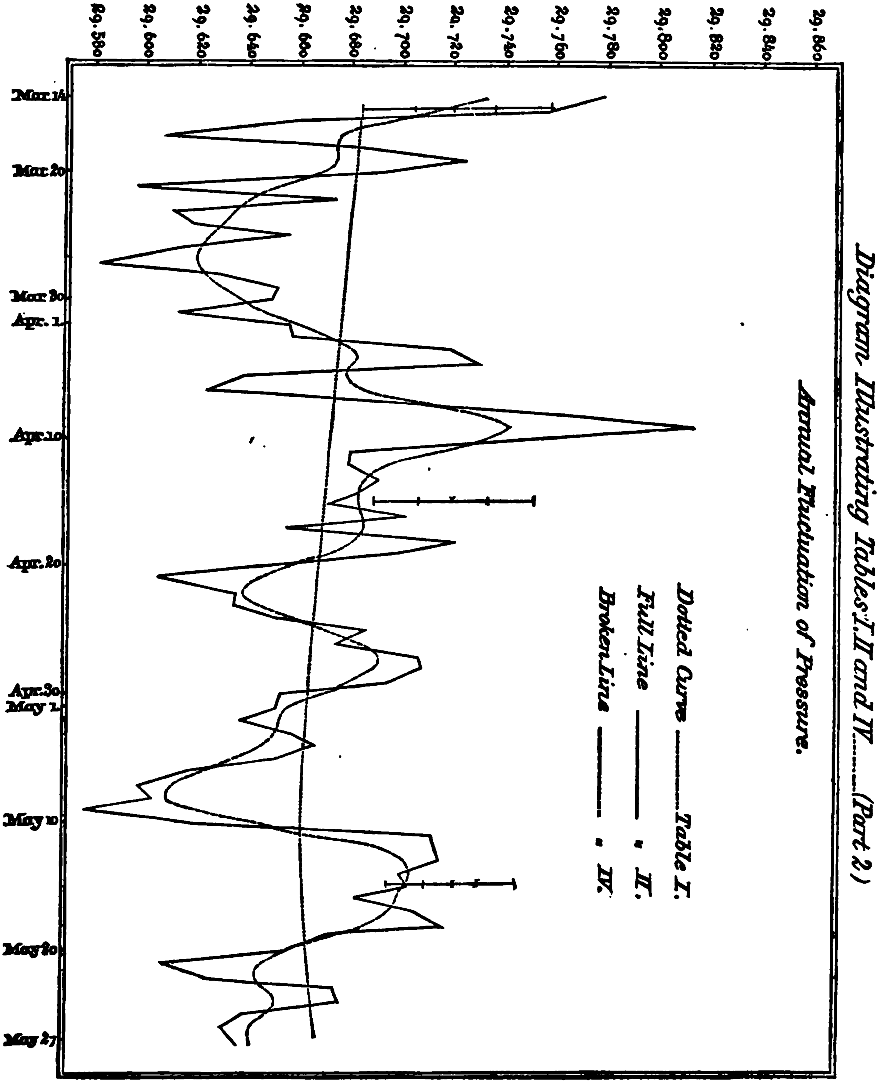


Diagram Illustrating Tables I. II and IV.......(Part 2)

Annual Fluctuation of Pressure.

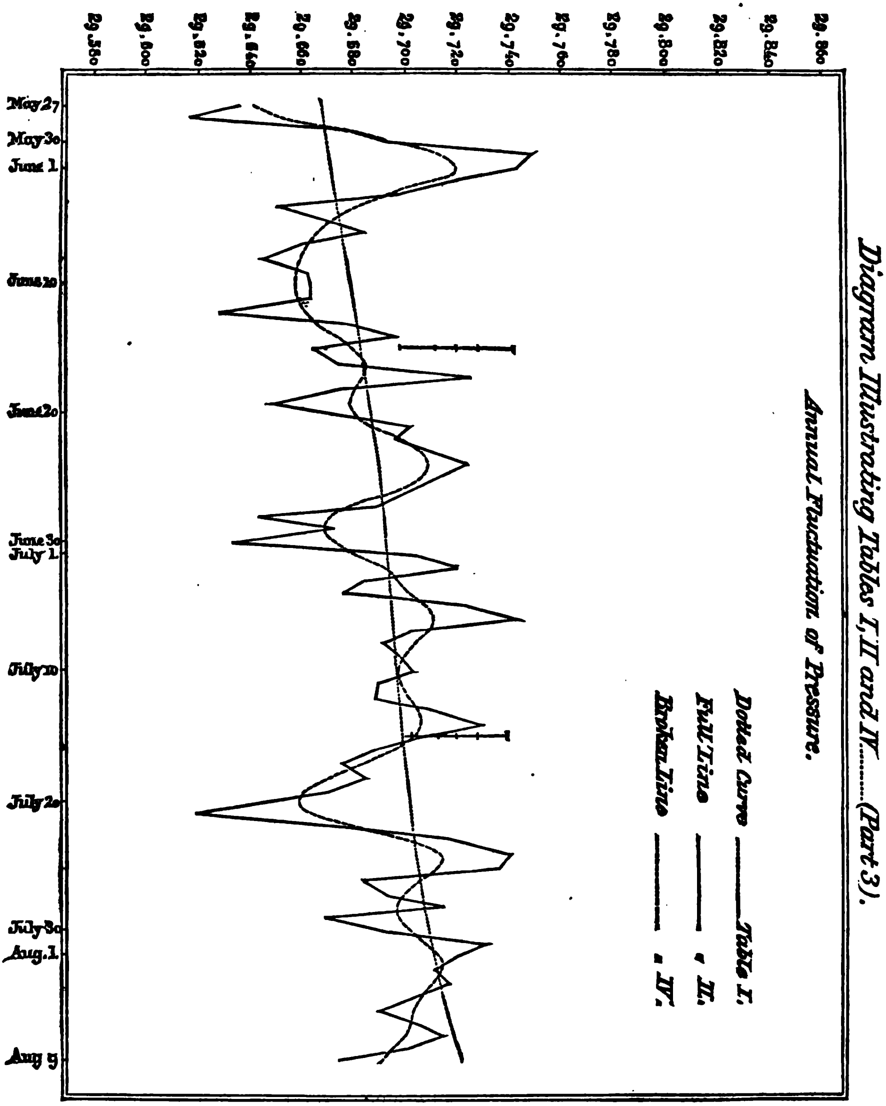


Diagram Illustrating Tables I, II and IV.......(Part 3).

Annual Fluctuation of Pressure.

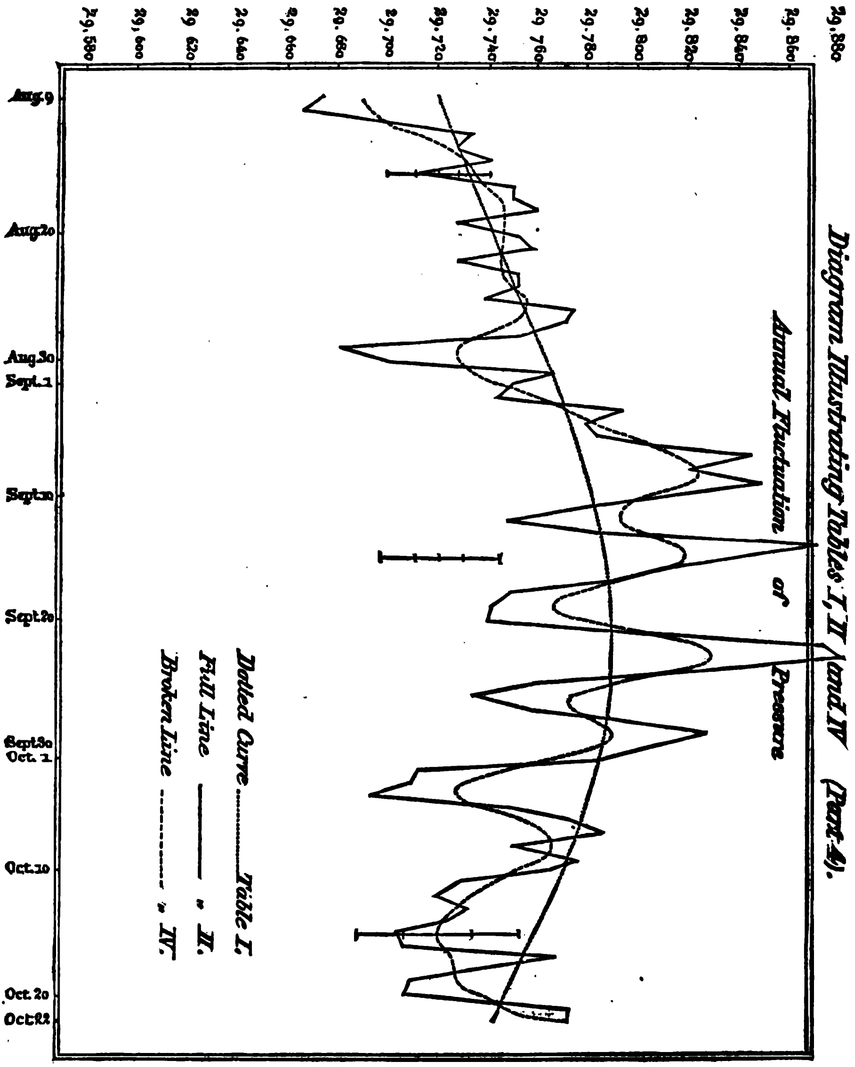


Diagram Illustrating Tables I, II and IV (Part 4).
Annual Fluctuation of Pressure
Dotted Curve .... Table I.
Full Line ——— " II.
Broken Line ---------- " IV.
29.580
29.600
29.620
29.640
29.660
29.680
29.700
29.720
29.740
29.760
29.780
29.800
29.820
29.840
29.860
29.880
Aug. 9
Aug. 20
Aug. 30
Sept. 1
Sept. 10
Sept. 20
Sept. 30
Oct. 1
Oct. 10
Oct. 20
Oct. 22

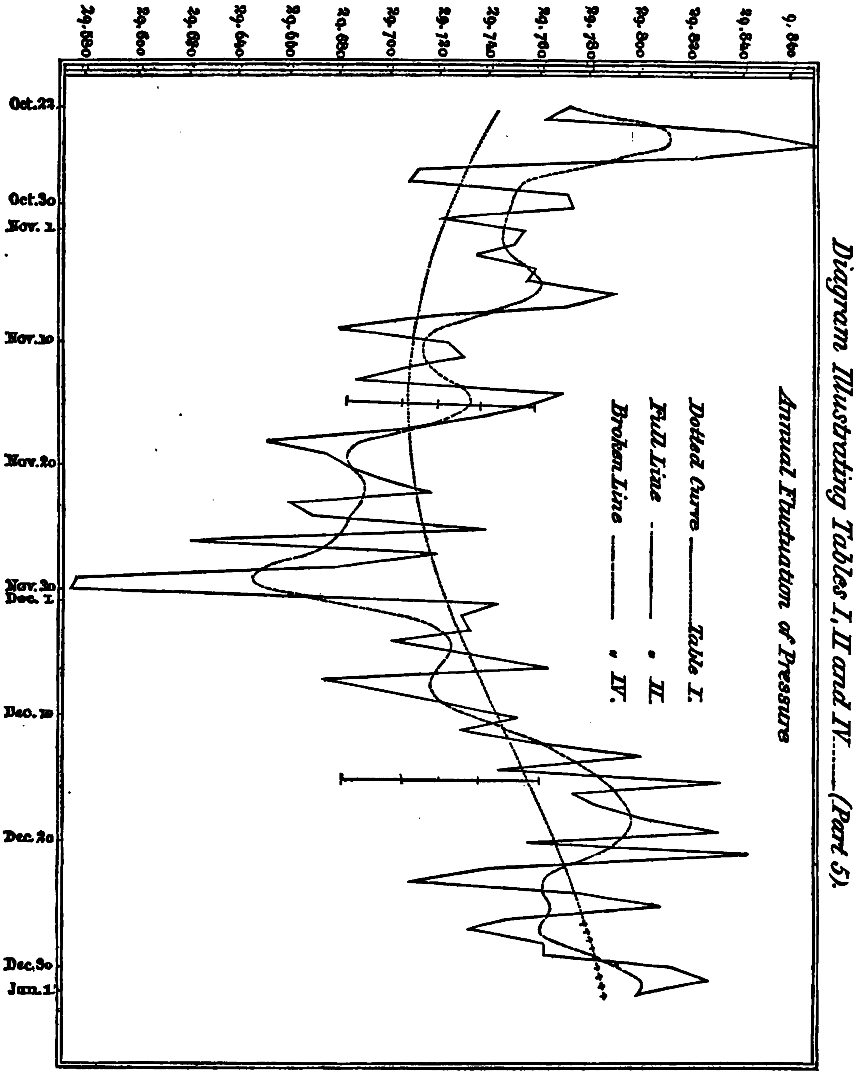
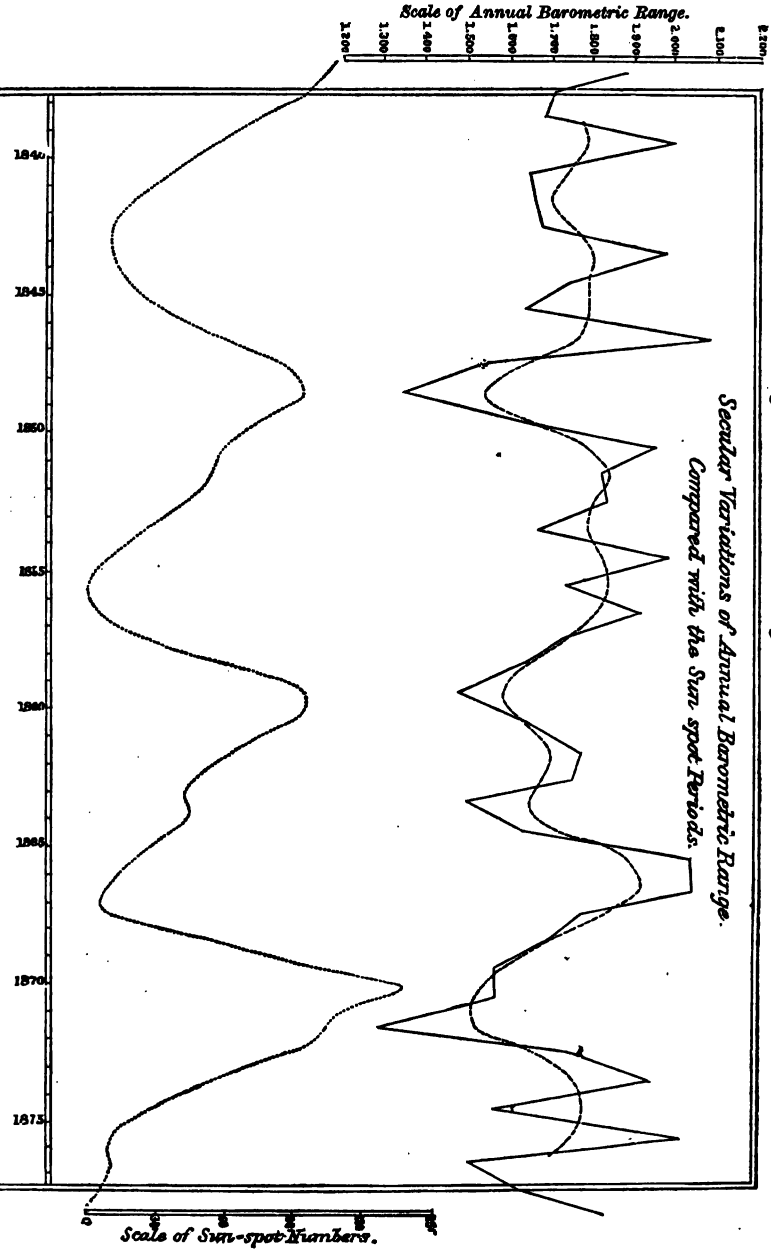


Diagram Illustrating Tables I, II and IV.....(Part 5).
Annual Fluctuation of Pressure
Dotted Curve ——— Table I.
Full Line ——— " II.
Broken Line ——— " IV.
9.860
29.840
29.820
29.800
29.780
29.760
29.740
29.720
29.700
29.680
29.660
29.640
29.620
29.600
29.580
Oct.22
Oct.30
Nov. 1
Nov.10
Nov.20
Nov.30
Dec. 1
Dec.10
Dec.20
Dec.30
Jan.1

Diagram Illustrating Table VII.

Secular Variations of Annual Barometric Range.

Compared with the Sun spot Periods.



The upper full line represents the actual ranges, and the accompanying curve the fourth order of means. The lower dotted line represents Wolf's Sun-spot numbers.

AN ACCOUNT OF INVESTIGATIONS RELATIVE TO ILLUMINATING MATERIALS.*

BY JOSEPH HENRY.

It has been the policy of the Light-House Board since its first establishment not only to adopt the latest improvements which have been made in other countries, but also to add by original investigations to the sum of knowledge on aids to navigation. In accordance with this policy, the Board has endeavored to keep itself informed as to the progress of the light-house systems of other countries, and in the erection of new towers and the supply of new apparatus to adopt those improvements which have from actual experience been preferred; and, furthermore, the committee on experiments have devoted a portion of every year to investigations which might develop new facts tending to greater economy or efficiency in the various appliances by which the dangers of navigation are diminished.

At the commencement of the operations of the Light-House Board, in 1852, sperm-oil was generally employed for the purpose of illumination. This was an excellent illuminant, but as its price continued to advance from year to year, it was thought proper to attempt the introduction of some other material. The first attempt of this kind was that of the introduction of colza-oil, which was generally used in the light-houses of Europe, and is extracted from the seed of a species of wild cabbage, known in this country as rape, and in France as colza. For this purpose a quantity of rape-seed was imported from France and distributed through the agricultural department of the Patent-Office to different parts of the country, with the hope that our farmers might be induced to attempt its cultivation. Although the climate of the country appeared favorable to its growth, and special instructions were prepared and distributed by the Light-House Board for its culture and the means of producing oil from it, yet the enterprise was not undertaken with any approximation to success, except in Wisconsin, where a manufactory of rape-seed oil was established by Col. C. S. Hamilton, formerly of the

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[*From the Report of the U. S. Light-House Board for 1875. The researches described in this memoir have a sufficient scientific value and popular interest to fully justify their reproduction here.—S. F. BAIRD.]

United States Army. To this manufactory the Light-House Board gave special encouragement, and purchased at a liberal price all the oil that could be supplied; the quantity however which could be procured was but a small part of the illuminating material required for the annual consumption of the Light-House Establishment.

The price of the sperm-oil still continuing to increase, the Board employed Prof. J. H. Alexander, a chemist of Baltimore, to make a series of investigations on different oils, to ascertain a method of detecting adulterations in them, and to determine the relative economical value of different kinds of oil which might serve for use in light-houses. In his report Mr. Alexander recommended, as a means of detecting adulterations in oil, a thermal test, which was based upon the amount of heat evolved by mixing a given quantity of the oil with sulphuric acid of a given specific gravity, and noting the rise of temperature as indicated by a standard thermometer in a unit of time. For using this method, it was proposed to ascertain by actual experiment the heat evolved by mixing pure oils with a given quantity of acid, and afterward oils adulterated with given quantities of lard or inferior oils. This ingenious suggestion was however never reduced to practice. The method was too refined; the difference of heat evolved was scarcely sufficient to be noted unless great precautions were taken to prevent loss by radiation and conduction, and consequently it could not be employed by ordinary inspectors. In regard to lard-oil, Mr. Alexander failed to employ the proper method of burning it, and consequently rated it very low on the scale of economical value as a light-house illuminant.

In this stage of the history of the subject we are presenting, the chairman of the committee on experiments commenced himself to investigate the qualities of different kinds of oil, and was soon led to direct his attention to the comparative value of sperm and lard oils. The experiments made by Mr. Alexander were with small lamps, and the comparison in this case, as will be shown, was much against the lard-oil.

The first experiment of the new series consisted in charging two small conical lamps of the capacity of about a half-pint, one with pure sperm-oil and the other with lard-oil. These lamps were of single-rope wicks, each containing the same number of strands; they were lighted at the same time, and the photometrical power ascertained by the method of shadows. At first the two were nearly equal in brilliancy, but after burning about three hours the flame of the lard had declined in photometric power to about one-fifth of that of the flame of the sperm. The question then occurred as to the cause of this decline, and it was suggested that it might be due—first, to a greater specific gravity in the lard-oil, which would retard the ascent of it in the wick, after the level of the oil had been reduced by burning in the lamp; or, second, to a want of a sufficient attraction between the oil and the wick to furnish the requisite supply as the oil descended in the lamp; or, third, it might be due in part to the imperfect liquidity of the oil, which would also militate against its use in mechanical lamps.

The lard-oil was subjected to experiments in regard to each of these points. It was found, by the usual method of weighing equal quantities of the two fluids, that the specific gravity of the lard was greater than that of the sperm; and also by dipping two portions of the same wick into the two liquids, and noting the height to which each ascended in a given time, that the surface attraction of the sperm was greater than that of the lard, or, in other words, the ascensional power of sperm was much greater than that of lard at ordinary temperatures. This method was also employed in obtaining the relative surface attraction of various other liquids; we say surface attraction instead of capillarity, because it was found in the course of these investigations that substances which had less capillarity—that is, less elevating power in a fine tube—had greater power in ascending in the meshes of a wick.

The relative fluidity of the different oils was obtained by filling in succession a pear-shaped vessel, with a narrow neck, of about the capacity of a pint, having a hole in the lowest part of the bottom of about a tenth of an inch in diameter. Such a vessel filled with any number of perfect liquids would be emptied in the same time, whatever their specific gravity. As at any given horizon, inertia is directly proportional to gravity, the heavier the liquid the greater would be the power required to move it, but the motive power would be in proportion to the pressure, or, in other words, to the weight, and therefore all perfect liquids should issue from the same orifice with the same velocity. To test this proposition, eight fluid-ounces of clean mercury, and then the same bulk of distilled water, were allowed to run out of the vessel above mentioned; the time observed was the same within the nearest second. It was found, in repeating this experiment with sperm and lard oils that the rapidity of the flow of the former exceeded considerably that of the latter; the ratio of time being 100 to 167.

The results thus far in these investigations were apparently against the use of lard-oil; it was observed however in the experiments on the flow of the two oils on different occasions, that a variation in the time occurred, which could be attributed only to a variation in the temperature at which the experiments were made. In relation to this point the effect of an increase of the temperature above that of the atmosphere on the flowing of the two oils was observed. By this means the important fact was elicited that as the temperature was increased the liquidity of the lard increased in a more rapid degree than that of the sperm, and that, at the temperature of about 250° F., the liquidity of the former exceeded that of the latter.

A similar series of experiments was made in regard to the rapidity of ascent of the oil in the wick, and with a similar result. At about the temperature of that before mentioned, the ascensional power of the lard was greater than that of the sperm. These results were recognized as having an important bearing on the question of the application of lard-oil as a light-house illuminant. It only required to be burned at a high temperature; and as this could be readily obtained in the case of larger lamps, there appeared to be no difficulty in its application.

The previous trials had been with small lamps, with single solid wicks, instead of the Fresnel lamp, with hollow burners. After these preliminary experiments, two light-houses of the first order, at Cape Ann, Massachusetts, separated by a distance of only 900 feet, were selected as affording excellent facilities for trying, in actual burning, the correctness of the conclusions which had been arrived at. One of these light-houses was supplied with sperm and the other with lard oil, each lamp being so trimmed as to exhibit its greatest capacity. It was found by photometrical trial that the lamp supplied with lard exceeded in intensity of light that of the one furnished with sperm. The experiment was continued for several months, and the relative volume of the two materials carefully observed. The quantity of sperm burned during the continuance of the experiment was to that of lard as 100 is to 104.

The freezing temperature of lard-oil depends upon the temperature at which it was expelled by pressure from the animal tissues in which it was contained. It is higher however than the freezing temperature of sperm, on an average of from 3° to 4°, but this is a matter of no practical objection to the substitution of lard for sperm, since the heat evolved from an Argand lamp is, in cases where the draught passes through the reservoir, sufficient to keep the lard liquid even during the lowest external temperature. Indeed, the small difference in temperature in freezing of the two oils is a matter of little moment, in cases which frequently happen when the temperature of the atmosphere is below zero on the Fahrenheit scale. At such a temperature, both oils would become alike solid, unless some means were afforded for preventing the freezing.

The next step toward the introduction of lard-oil was the devising of a system by which it could be inspected, and the Board assured, before it should be too late to remedy the evil, that the lard purchased was of a good quality. This was a matter of great importance, and involved no small degree of responsibility, since the contractor was entitled to his pay immediately after the acceptance of the oil, and while the quantity purchased amounted annually to nearly 100,000 gallons.

The conclusion was arrived at that it was impossible, from any single test that could be applied to small samples, to determine the quality of the oil as applicable to light-house purposes; and that in the present state of our knowledge as to its character the following tests are required to fully insure in all cases the required quality of the article:

1. Specific gravity at 60° F.
2. Liquidity at different temperatures.

3. Freedom from acids or alkalies.
4. Resistance to freezing.
5. Actual burning in fifth-order lamps for at least ten hours.
6. Photometric power after burning one hour, and again after burning ten hours.
7. The condition of the wick at the end of the burning.

These tests are of very unequal value, and several of them might be dispensed with, were others reduced to an absolute standard determined by the actual experience of burning in the light-houses.

The specific gravity of impure lard and of that which has been carefully refined differ but little, and hence, unless the experiment be made by means of a delicate balance, the indications will be of comparatively little value. Still, as a given sample might contain some foreign substance which is not usually mixed with this oil, the test with the hydrometer should not be omitted.

In making this test, a cylindrical vessel containing the oil, of sufficient diameter to permit the hydrometer to float freely without hinderance from the sides, should be immersed in a vessel containing several gallons of water, which, when once reduced to 60° by the addition of ice-cold water, can, on account of the great specific heat of water, be readily kept at that temperature by a slight addition of cold water from time to time, the whole being continually stirred. It is scarcely necessary to state that the vessel containing the oil must be so weighted at the bottom that it will stand erect in the cold bath in which the experiment is made.

Liquidity at different temperatures is a test similar in character to that of specific gravity; although the difference in degree of liquidity of different kinds of oil, such as sperm, whale, and lard, is very considerable, the difference between different samples of lard-oil is small. Still, this test, for a similar reason to that given for the specific gravity, should be applied.

The test for free acids and alkilies is easily made, and should in no case be omitted. A portion is put into beaker-glasses, with a slip of litmus-paper in one and a slip of tumeric paper in the other, and suffered to remain immersed perhaps twenty-four hours; and at the end of that time, if one of these papers exhibits no redness and the other no brownness, the oil may be considered void of free acid and of alkali, both of which would lessen its value, the former tending to corrode the lamp and the latter interfering with its burning quality.

Resistance to freezing is an important test, but not as easily applied in the case of lard-oil as might at first be imagined. Lard-oil possesses the remarkable property of resisting the influence of a low temperature if suddenly applied, while it will freeze at a much higher temperature if the cold be continued for several hours.

For example, if a small portion of lard-oil be placed in a test-tube and submitted to a rapid diminution of temperature by being plunged in a freezing-mixture, it will remain liquid at a temperature of 19° or 20°, whereas it will congeal at a temperature of 40° if suffered to remain at that temperature for several hours.

The plan adopted for determining the freezing-point of different samples of oil at one operation consisted in making a series of small openings, or windows, closed with glass, in the side of a cylindrical wooden tub about 2½ feet in diameter. Concentric within this tub was placed another cylindrical vessel, of smaller diameter, of zinc, filled with a freezing-mixture of salt and pounded ice. A series of small beaker-glasses, filled with the several samples of oil, were placed opposite the windows in the space between the two cylinders, each containing a thermometer which could be read through the window. The whole was then inclosed by a tightly-fitting cover, through which projected the handle of a crank by which the freezing-mixture could be stirred. The samples of the oil subjected to this cold-air bath gradually pass through the several stages of a diminution in limpidity and clearness to opacity and solidity, the time of each being noted.

The most reliable test is that of actual burning in a lamp of the fifth order, and the measurement of the photometrical power. The objection to the application of this test to the oil of every barrel is the large quantity of oil required and the amount of labor involved in the proper execution of the process. Thus, in testing 60,000 gallons contained in casks of forty gallons each, at least 500 gallons would be required. It is therefore evident that this test can only be applied to samples selected from a given lot, while the single barrels are proved to be of a similar character by the more simple tests.

Another method of insuring that all the casks of a given lot contain oil of the same quality, consists in taking a small equal portion from each of several casks and mingling them together; the quality of the compound being ascertained by the application of burning or the other tests.

The determination of the photometrical power is, in the present state of science, unless precaution is observed, a problem of some uncertainty. The difficulty is of two kinds, the first to find a photometer which shall give the ratio of the two lights, and, second, to find an invariable standard to which oil of the proper quality may always be referred. These difficulties, I think, can be sufficiently overcome for the practical purposes of the Light-House Board. The greater difficulty is that of obtaining a standard of reference. For this a sample of lard-oil manufactured by Mr. Alden, of Boston, was at first employed, but this, itself, was found to be variable, and hence we were obliged to adopt some other standard. The one which has been finally adopted is English sperm candles, which burn with considerable uniformity at the rate of 120 grains per hour, or two grains per minute.

In regard to the investigation, the experiments were carried on under many difficulties. They were made at first in the engineer's office of the second light-house district in Boston, with such appliances as could be procured at the moment, with the assistance of Mr. William Goodwin, the acting light-house engineer, who took much interest in the subject and rendered efficient service.

In the erection of a new lamp-shop at the Staten Island depot, care was taken to make provision for a dark room in which the photometrical examinations could be made with more precision than had been obtained in the temporary apartments previously used. This room extends the whole length of the building, is about 80 feet long by 12 wide; the windows are closed by iron shutters to exclude the light; and the walls, floor, and all other parts are painted black, after being sanded to remove any glare which might exist.

In the first experiments on lard-oil the photometrical process employed was that of Rumford, which consists in ascertaining the relative intensity of two lights from their distances from a screen on which shadows of equal darkness are thrown by an intermediate body. In this case the relative intensities sought are indicated by the square of the distances in inches and parts of inches of each light from the screen on which the shadows are cast. But this method, which is used by the French manufacturers of apparatus, and is very simple in theory, does not admit of much accuracy.

The arrangement, therefore, known as Bunsen's photometer, was introduced in its stead, and this, with some peculiar modifications, leaves nothing to be desired. This arrangement consists in placing two lights at the extremity of a scale so divided into distances that the relative intensity of the two flames may be immediately read off in terms of candle-power when a small intermediate movable screen is equally illuminated on both sides. This screen is usually formed of a piece of white pasteboard of about four inches square, fixed perpendicularly at right angles to the length of the scale, in a sliding frame, by which it can be brought nearer to or farther from one of the lights. In the center of this square is a circular hole of about half an inch in diameter, which is closed by a piece of thin paper, rendered translucent by a solution of spermaceti in oil of turpentine. This forms a spot which is darker than the other parts of the white screen, and is equally dark on both surfaces when the screen is receiving an equal quantity of light from each flame; the screen is moved backward and forward until this effect is produced, and the index will then point on the graduated scale to the number of the relative power of one of the lights in the terms of the other.

The screen may also be made of thin paper, the whole of which is rendered translucent except a round spot in the center, of half an inch in diameter. If a light is placed before the screen on one side, the whole of the greased part will appear dark, on account of part of the light going through the translucent portion. If, now, another light be placed on the opposite side, an equal portion will be transmitted through the pellucid part, and the two surfaces will appear of like intensity when the two lights are equal, or when from their respective distances they throw equal amounts of light on the two faces of the screen.

In order that both sides may be seen at the same moment without moving the head on one edge of the screen, two mirrors, making with each other an angle of 90°, are placed so that the screen itself will bisect the angle.

For dividing the scale into parts related to each other as the square of their distances from a center, the following formula and table will furnish the means. Let a be the length of the scale, and x the distance from the candle end to the movable screen; then $a-x$ is the distance between the lamp end and the end of the screen. Denote the degree of illuminination on the candle and lamp sides of the screen by L and L′ respectively. Let the intensity of the candle end equal one candle, while that of the lamp is n candles. Then, since the illumination of the screen varies directly as the intensity and inversely as the square of the distance, we have the following proportion:

$\mathrm{L}:\mathrm{L}'::\frac{1}{x^2}:\frac{n}{(a-x)^2}$, and when $\mathrm{L}=\mathrm{L}'$ we have $(a-x)^2=nx^2$ whence $x=\frac{a}{1+\sqrt{n}}$ For convenience of using this formula it is best to change its form into $x=a\,\frac{\sqrt{n}-1}{n-1}$

The following table has been computed by calling the length of the scale 100 and assigning successive integral values to n, from 1 to 100 The column A shows the value of x for each assumed value of n:

Number of candles.	A	Number of candles.	A	Number of candles.	A	Number of candles.	A
1	50.00	26	16.40	51	12.28	76	10.29
2	41.42	27	16.14	52	12.18	77	10.23
3	36.60	28	15.89	53	12.08	78	10.17
4	33.33	29	15.66	54	11.98	79	10.11
5	30.90	30	15.44	55	11.88	80	10.05
6	28.99	31	15.23	56	11.79	81	10.00
7	27.43	32	15.02	57	11.70	82	9.94
8	26.12	33	14.89	58	11.61	83	9.89
9	25.00	34	14.64	59	11.52	84	9.84
10	24.03	35	14.46	60	11.43	85	9.79
11	23.17	36	14.29	61	11.35	86	9.73
12	22.40	37	14.12	62	11.27	87	9.68
13	21.71	38	13.96	63	11.19	88	9.63
14	21.08	39	13.80	64	11.11	89	9.58
15	20.52	40	13.65	65	11.04	90	9.54
16	20.00	41	13.51	66	10.96	91	9.49
17	19.52	42	13.37	67	10.89	92	9.44
18	19.07	43	13.23	68	10.82	93	9.40
19	18.66	44	13.10	69	10.75	94	9.35
20	18.27	45	12.97	70	10.68	95	9.31
21	17.91	46	12.85	71	10.61	96	9.26
22	17.58	47	12.73	72	10.54	97	9.22
23	17.25	48	12.61	73	10.48	98	9.17
24	16.95	49	12.50	74	10.41	99	9.13
25	16.67	50	12.39	75	10.35	100	9.09

The standard adopted with which to compare all other lights is, as we have said, that of the London sperm candle, which, under ordinary conditions, burns 120 grains of sperm per hour. If it burns more or less than this amount during the trial, a correction of a proportional amount is made in the results.

This standard however is too small for determining the power of large lamps, and for this purpose an intermediate standard is provisionally adopted. For example, in determining the power of a lamp of the first order, the power of a lamp of the fourth order is first obtained, and this is used as a comparison with the larger lamp.

In the case of the arrangement at the Staten Island depot, for photometrical measurements, three scales are employed, diverging from a center at which the lamp to be measured is temporarily placed; at the farther end of each scale is placed a sperm candle, to serve as the standard of comparison. These scales are of different lengths, one being 100 inches in length, another 150 inches, and the third 200 inches; besides these, one of the scales is occasionally replaced by one of 700 inches in length, which is put up in sections.

As the semi-diameter of the burner of the lamp and that of the candle must be included in the length of the scale, a portion of the latter at each end is cut off. In adjusting the scales, therefore, to their places, the measurement must be taken from the middle of each scale; thus, in the case of the one of 200 inches in length, the middle of it must be just 100 inches from the center of the lamp on one side, and 100 inches from the center of the candle on the other. In making the examination, three observers simultaneously, one at each scale, take the photometric readings, and the mean of the three results is adopted as the candle-power of the light under examination.

In the examination of oil previous to purchase, as we have said before, a lamp of the fifth order is charged with the oil in question, and when in a state of equilibrium of combustion it is subjected to the trial. For greater precision ten readings are taken on one side of the scale, and then the photometer is reversed and as many taken from the opposite side. In this way the mean of sixty readings, twenty on each scale, furnishes the data on which the character of the oil principally rests. As a means of simultaneously weighing the candles for checking the effects of their irregular burning, three balances are provided, each of which bears one of the candles in a socket supported by a metallic link, through which the scale-beam passes and is attached to the hook of the scale-pan below.

On the opposite scale-pan a series of grain weights are placed, which can be taken off without disturbing the equilibrium of the scale, by a pair of pincers; the interval of time during which a given grain weight is burned is marked by a watch. If the interval is equal to two grains for each minute, the candle is burning at its normal rate; if not, a correction is made by simple proportion, which is applied to the measurement previously obtained.

The lamps containing the oil for trial are lighted and trimmed in an adjoining apartment. They are introduced into the dark room through a window closed with a sliding shutter. In order to prevent an overflow of oil at the burner by the oscillation of the liquid in the reservoir by the agitation of transfer, each lamp is placed on a small carriage moving on a railway, which, passing through the window, enables the lamp to be placed in its position with rapidity, and without the slightest disturbance of the equilibrium of the oil.

The temperature of the room is also noted, and, as far as possible, it is kept at a heat of not far from 70°. For this purpose, during warm weather the inspection may be made at night.

For reading the divisions on the scales in the dark room, a mirror is employed to throw the light of the lamp under inspection on the graduation.

To exclude all extraneous light, the three candles and the lamp to be tested are each surrounded by a cylindrical sheet-iron screen, painted black, through which a hole a little larger than the flame allows the light to pass along the scale to the photometer. The trial-lamps are those of the fifth order. Each, after it has been lighted, is allowed to burn an hour before being submitted to the photometrical measurement. If it gives a power less than 8 candles, the oil is rejected. If it passes that test, it is then allowed to burn undisturbed without being trimmed for 8 or 9 hours longer, and if it is found at the end of that time to exhibit no diminution in the brilliancy of the light it is considered worthy of adoption, especially if after this it continues to burn 4 or 5 hours with no perceptible diminution which can be detected with the naked eye. The best lard-oil will burn 16 hours without trimming.

Each candle before the measurement commences is suffered to burn until it has assumed a perfect and uniform rate of consumption; it should be prevented from guttering by removing a portion of the melted spermaceti which may accumulate in the cup at the top of the candle beyond the power of the feeble incipient flame to consume, by absorbing it by one end of a strand of candle-wick cautiously introduced. If any portion of the spermaceti is suffered to run down the side of the candle and drop off below, the correction for variation in burning will be worthless.

All materials for the use of the Light-House Establishment are purchased by contract in accordance with published specifications as regards quality and certain conditions. The award is given to the lowest bidder, provided he can offer trustworthy surety as to his ability to fulfill the contract. Preference is however given when bids are equal, or nearly so, to the bidder who is a manufacturer of the oil and not a mere vender of the article. During the inspection permission is granted to the contractor to be present at the operation, in order that he may be assured that full justice is done him in the examination. After seeing the precision with which the photometric and other processes are conducted, he is generally fully satisfied as to the results obtained, even though his oil may have been rejected.

The oil is delivered in iron-bound casks, varying from 38 to 50 gallons. These are placed, previous to inspection, under a shed and arranged in different lots, each containing oil of the same quality. From different casks samples are taken in tin canisters of a capacity of about half a gallon; each canister being marked with the number of the lot and the cask from which the oil was taken. Before the sample is drawn from the cask the oil within is thoroughly mixed by rolling the cask, or by stirring. The object of this is to obtain in the sample an average amount of solid matter which may be contained in the oil.

The purest lard-oil is that which is manufactured by submitting the solid leaf lard to great pressure during the coldest period of winter. Oil of this quality is used for burning in small mechanical lamps; it gives a bright flame and does not incrust the wick. The light-house lamps however being of a much larger size and evolving a much greater amount of heat, can consume oil of a coarser character; and indeed it has been found that oil containing a certain amount of solid matter, provided the latter is not too much in quantity to be consumed by the lamp, gives a higher illuminating power. On this account, before this fact was generally known in the trade, complaints were made of the Light-House Board giving the preference to oil which, in the market, would not be considered of the first quality.

The quantity of oil is estimated by weight, allowing 7.6 pounds per gallon. It is weighed in gross and afterward emptied into large tanks in an underground vault. The empty barrels are next weighed; the weight of these deducted gives the net weight of the oil.

Previous to the establishment of the general light-house depot at Staten Island, from which all the supplies are now distributed, and the lamps and other light-house appliances are prepared for immediate use, the oil was received at various ports along the coast, in accordance with terms of the contract, and was stored until wanted for use, in cellars hired for that purpose.

The Board however after the introduction of lard-oil, constructed a spacious underground receptacle capable of containing 50,000 gallons of oil, and retaining it during the whole year at a temperature not to exceed 65° Fahrenheit.

The underground vault contains five tanks, each of the capacity of ten thousand gallons. On each tank is a register, consisting of a glass tube so divided as to give the contents in hundreds of gallons. The oil is delivered in three installments: The first on the 1st of May, the second on the 10th of June, and the third on the 22d of July. The vault and tanks were constructed under the direction of General Poe while engineer secretary of the board, who also took a lively interest in the introduction of lard-oil and in the preliminary experiments for determining its quality.

A photometer room was afterward fitted up in the Smithsonian Institution, in which several series of investigations were made in regard to the illuminating power of different oils. At the same time a series of experiments was undertaken relative to their chemical characters and conditions; in which experiments the chairman was assisted by Prof. C. M. Wetherill, whose untimely loss the science of this country has been called to mourn. Among the investigations in the laboratory are the following, relative to the expansions of different oils, intended to facilitate the purchase, the measurements being made at different temperatures. To obviate the necessity of the correction for temperature, the oil is now purchased by weight. The following results may however be of value in the application of different oils to light-house purposes:

EXPERIMENTS UPON LIGHT-HOUSE OILS.

[Density and volume of oils (and water), at different temperatures.]

Temperature, C.	Sperm oil.		Whale (unrefined).		Lard (refined).		Lard (unrefined).	
	Volume.	Density.	Volume.	Density.	Volume.	Density.	Volume.	Density.
4°	1.0000	0.89256	1.0000	0.92825	1.0000	0.92488	....	....
10°	1.0053	0.88783	1.0049	0.92370	1.0042	0.92103	1.0000	0.92086
15°	1.0095	0.88418	1.0095	0.91952	1.0093	0.91632	1.0051	0.91614
20°	1.0134	0.88072	1.0145	0.91498	1.0124	0.91356	1.0109	0.91090
25°	1.0168	0.87778	1.0166	0.91311	1.0164	0.90992	1.0146	0.90760
30°	1.0208	0.87432	1.0200	0.90999	1.0204	0.90641	1.1169	0.90556
35°	1.0243	0.87139	1.0236	0.90688	1.0237	0.90351	1.0204	0.90247
40°	1.0286	0.86721	1.0297	0.90146	1.0278	0.89986	1.0244	0.89897

Temperature, C.	Kerosene.		Water (C. M. W.).		Water (Kopp).		Alcohol (Pierre), vol. at 0° C. = 1 vol.	
	Volume.	Density.	Volume.	Density.	Volume.	Density.	C.	Density.
4°	1.0000	0.81199	1.00000	1.00000	1.0000	1.00000	0°	1.0000
10°	1.0050	0.80799	1.00048	0.99952	1.0003	0.99975	10°	1.0107
15°	1.0106	0.80347	1.00086	0.99915	1.0008	0.99918	20°	1.0217
20°	1.0152	0.79984	1.00176	0.99824	1.0017	0.99831	30°	1.0331
25°	1.0187	0.79709	1.00303	0.99698	1.0028	0.99717	40°	1.0448
30°	1.0234	0.79346	1.00447	0.99555	1.0042	0.99579	....	....
35°	1.0276	0.79020	1.00619	0.99384	....	....	....	....
40°	1.0321	0.78674	1.00774	0.99232	....	....	....	....

ORGANIC ANALYSES OF LIGHT-HOUSE OILS.

No. 1.—*Refined winter-pressed lard-oil.*

	First experiment.	Second experiment.	Mean.	By calculation.
Carbon	76.87	76.53	76.75	C_{44} 76.74
Hydrogen	11.58	11.63	11.61	H_{40} 11.63
Oxygen			11.64	O_5 11.63
Formula = $C_{44} H_{40} O_5$			100.00	100.00

No. 2.—*Crude lard-oil.*

Carbon	77.07	76.70	76.88	
Hydrogen	11.72	11.69	11.71	
Oxygen			11.41	
			100.00	

No. 3.—*Sperm-oil.*

Carbon	79.52	79.41	79.46	C_{53} — 79.70
Hydrogen	12.28	12.28	12.28	H_{49} — 12,28
Oxygen			8.26	O_4 — 8.02
Formula = $C_{50} H_{49} O_4$				100.00

EXPERIMENTS OF MIXING OILS WITH OIL OF VITRIOL OF 66° BEAUMÉ, AT 62° F.

First experiment.—Winter-pressed lard-oil.

[Of oil, 2 fluid ounces; of acid, 1 fluid ounce:]

Temperature of oil before mixing	70° F.
Temperature of oil after slow mixing	130°
Difference	60°
At the expiration of 3 minutes, temperature	134°
At the expiration of 4 minutes, temperature	134°

Second experiment.—Winter-pressed lard-oil.

Temperature before mixing	70° F.
Temperature after mixing rapidly	169°
Difference	99°

Third experiment.—Winter-pressed lard-oil.

Temperature before mixing	70° F.
Temperature after mixing	165°
Difference	95°

Fourth experiment.—Crude lard-oil.

Temperature before mixing	66° F.
Temperature after mixing	164°
Difference	98°

REFRIGERATION OF THE OILS.

Those experimented upon were whale, sperm, refined lard, and crude lard.

First experiment.

At 30°.2 F. they were all sirupy; in the crude lard-oil a yellowish solid began to separate.

At 26°.6 the sperm-oil began to solidify.

At 24°.8 the refined lard began to yield a white precipitate.

At 17°.6 the whale-oil was a thick sirup, without deposit. The crude lard-oil was quite hard. The pure lard-oil was not as hard as the crude lard-oil. The sperm-oil was not as hard as the pure lard-oil. These experiments performed in test tubes.

Second experiment.

Upon pure winter-pressed lard-oil, in a test tube.

At 17°.6 F., begins to deposit flakes of solid matter.

At 14° is quite thick.

At 10°.4 it is perfectly solid.

If, now, the temperature rises, a small portion of the oil remains solid until the temperature reaches 44°.6.

Third experiment.

The oils were placed in large cylinders and exposed to a temperature of 24°.8 F., with the following results:

1. Crude lard-oil, much sediment.
2. Sperm-oil, ditto.
3. Pure refined lard-oil, a little sediment.
4. Winter-strained lard-oil, very little sediment.
5. Whale-oil, no sediment.

In the use of sperm-oil, it was found that the purer it could be obtained the better, and hence it was the custom to strain the oil through clean white sand previous to using it, and also the drippings. In the case of lard however, it was found that removing all the solid matter diminished its photometric power.

All fatty oils absorb oxygen, which unites with them to form oxides of their combustible ingredients; oil therefore freely exposed to the air, must in time gradually diminish in its power of combustion. It should not, therefore, be open to the atmosphere when the oil is to be stored, but covered with a thin wooden plane, which floats upon the surface of the oil, and thus in a great measure excludes the air. The freezing of lard-oil does not appear to affect its quality.

Considerable difficulty was experienced in the introduction of lard-oil, on account of the objection to it on the part of the keepers; in some cases from the want of experience in using it, and in others from the interference of venders of sperm-oil. This difficulty however was obviated by a resolution of the board, by which any keeper that declared his inability to burn lard-oil should be requested to resign, since it had been abundantly proved that this oil, with proper management, could be made favorably to compete with sperm. Its introduction was a matter of great importance in an economical point of view; it saved the government $100,000 annually for several years.

Another important step in the introduction of lard-oil was that of furnishing a lamp which would burn it with the greatest perfection. This was due to the invention of Mr. Joseph Funck, foreman of the lamp-shop. As we have said, in order to burn lard-oil it is necessary it should be kept at a high temperature, and for this purpose the heat of the draught of the lamp was passed through the center of the reservoir.

Previous to the change in the illuminating material there had been used in the Light-House Establishment three classes of lamps, viz, the mechanical lamp for the first, second, and third orders, and the moderator and fountain lamps for the fourth, fifth, and sixth orders.

In the mechanical lamp the oil was placed in a reservoir below the burner, and pumped up by means of clock-work. This apparatus is of a complicated character, and is subject to derangement. The valves must be renewed from time to time, and the clock-work cleaned. The proper performance of these operations is beyond the skill of an ordinary keeper, and requires the frequent aid of a trained lampist.

The moderator lamp is less complicated, and was invented to obviate the difficulties just mentioned. In this the oil is elevated by the descent of a heavy piston, and forced up through a small conical hole, the flow being regulated by the conical end of a wire, which is gradually withdrawn as the weight descends, so as to give a less-obstructed flow as the hydrostatic pressure of the oil increases. From this arrangement it takes its name of moderator lamp. This apparatus however is liable to irregularity on account of derangement of the supplying apparatus, the varying friction of the packing of the piston, as well as the change in the flow of the quantity of oil, owing to its less liquidity due to a diminution in temperature.

The reservoir of the fountain-lamp consists in an air-tight vessel, usually cylindrical, from the bottom of which descends a tube, terminating at the open end in a small cup, from which the burner is directly supplied with oil on the well-known principle of the bird fountain, this vessel being filled with oil by inverting it and pouring in the liquid through the open end of the tube. It is then reinverted and the end of the tube inserted in the small cup below the level of the oil which it contains. The oil in the reservoir in this condition is supported by the pressure of the atmosphere on the surface of the oil in the cup. When this surface is lowered by burning, the end of the tube is opened, and a bubble of air passes up and an equal bulk of oil descends, and in this way a nearly constant level of oil is maintained. I say nearly constant because the air which goes up is of some volume and in the act of passing up produces an oscillation which, in some degree, affects the steadiness of the burning of the flame.

There is however a greater defect in this lamp from the oscillations in the level when the reservoir has been exhausted of a considerable portion of its charge of oil. In this case the arrangement is one similar to an air thermometer with a large bulb, and is affected by a sudden draught produced by the opening and shutting of a door or the ordinary ventilation of the lantern. This was partly remedied by bending the tube, and thereby increasing the resistance to a sudden change in the level of the oil.

The improvement of Mr. Funck consisted in substituting for these lamps one of constant level, in which the oil is placed above the burner, and the flow of oil necessary for perfect combustion is regulated by a small floating piston, placed in an enlarged portion of the supply-tube, and carrying on its upper surface a conical projection which increases or diminishes the size of the supplying orifice in accordance with the rapidity of combustion. This lamp is not only free from the objections pertaining to the other lamps, but is less expensive and better adapted to the burning of lard-oil. It affords a freer combustion, and consequently a more intense light, though at the cost of a larger amount of the burning material.

In this lamp the heated air and products of combustion pass through a cylindrical opening in the reservoir, which is placed directly above the lamp, the opening in it forming as it were a prolongation of the chimney, thus not only preventing the oil from freezing in the coldest weather, but supplying it to the burner at the temperature best adapted for perfect combustion.

In regard to the comparative character of lard and colza oil, we may be allowed to print the following letter from Colonel Hamilton, the manufacturer of the latter oil, who was present at the trial to which he alludes:

FOND DU LAC, WIS., *May* 16, 1868.

DEAR COMMODORE: I must confess my great disappointment at the result of the experiments at Staten Island. It is however not really so much the failure of rape-seed oil, as the undeniable excellence of lard-oil as a burner. I fully believe that our rape-seed oil of this year is as good as any that was ever made in Europe, and I know it is far better than any we have ever before made. I am satisfied now that, for self-heating lamps, there is no oil that will bear comparison with lard, but I am equally satisfied that no colza oil will yield a better result than ours, under exactly the same tests. We have but one more experiment to make with colza; it is its extraction by chemical displacement. If this fails, we shall abandon the whole business.

If all things are put together, I think the following statement will be allowed, to wit: Our colza oil is equal to any foreign colza. It is better than any we have heretofore made. It is better than sperm or any other burner, excepting only lard-oil. Our failure then is owing to the superior excellence of lard-oil, which, under the persistent investigation of the board, has been shown to be the best and cheapest safe illuminator available.

The board are entitled to great credit in producing this result. It will be remembered that but a few years since lard-oil was pronounced unsuitable for light-house purposes, but the perseverence of the board has brought out the fact that it is much the best and cheapest oil, and that the expenses of lighting the coast and harbors have been thereby greatly reduced. Surely the country at large should acknowledge this, and give due credit to the board. We have endeavored to do with colza what the board have effected with lard-oil, and we have been unsuccessful both for ourselves and the light-house interest. The undertaking has been no source of profit to us, and had the capital and time that have been devoted to colza been used in our other branch of manufacture (linseed oil), it would at least have reimbursed us with a fair remunerative return. As regards the oil we have offered, we have hoped the board would take it. I do not think we can improve upon the quality, and it is the last we shall venture to offer to the acceptance of the board, for we shall henceforth abandon the manufacture, except for local wants.

We are grateful to each member of the board for the interest they have always shown in our undertaking, and for their uniform kindness and courtesy. Accept, my dear commodore, for yourself and your associates in the board, my warmest thanks for your many kind expressions of interest, and believe me, truly and gratefully, yours,

C. S. HAMILTON.

Com. A. A. HARWOOD, *U. S. N.*,
Secretary Light-House Board, *Washington*, *D. C.*

From the date of the introduction of lard-oil in 1865, '66, and '67, until the end of 1873, when the attention of the board was again directed to the study of mineral oil, continual improvements were made in the processes of its preservation and inspection, and also in the lamps and other appliances for its employment, and nothing further as a light-house illuminant was required. It is therefore with regret that we are urged, on account of the increased price of the article, due in some degree to the reputation as a burning material given it by the board itself, to substitute for it a less reliable but a much more economical material.

At the time lard-oil was introduced a series of experiments was made on the comparative value of the different petroleum oils used in this country. They were however all considered too dangerous to be intrusted to the ordinary keepers of the light-stations of our coast. Since the date however of these investigations, improvements have been made in the manufacture of these oils, by which a much greater range has been obtained in the temperature at which they give off an explosive vapor. During the last two years, therefore, a new series of investigations has been made relative to these illuminating agents, of which we propose in the succeding pages to give a brief account.

The crude petroleums of the Pennsylvania oil region are of a greenish or yellowish appearance, and have a specific gravity of 45° to 49° Beaumé, at a temperature of 60° Fahrenheit. Some are so volatile as to evaporate rapidly at the ordinary temperature of the air, rendering it dangerous to approach an open cask of crude petroleum with a flame; others are much less volatile, requiring a temperature of from 200° to 300° F. to vaporize them. The volatility of the hydro-carbons is intimately connected with their specific gravity. They become heavier as the volatile ingredients are driven off by heat. The inflammability of the oils is also connected with their volatility and the specific gravity. The light volatile oils ignite, as we have said, on the approach of a burning match at ordinary temperatures, while the heavier require a higher temperature for ignition. The process of manufacturing these oils consists in separating them from each other as they occur in the crude oil of the springs by what is called fractional distillation; for this purpose the crude oil is placed in an iron still provided with a worm of the same metal submerged in a tank of water for cooling it; the still is then gradually heated; the first product that passes over is gaseous at ordinary temperatures, and can only be condensed into a liquid form by cooling the worm with ice, or by compressing the gas with an air-pump into a strong receiver. After all the vapor is given off at the temperature, say at 90° F., the temperature of the liquid in the still is raised, a liquid is produced which exhales in vapor at a higher temperature and is of greater density—and so on, a series of liquids are produced, each of which requires to be heated to a higher degree before taking fire on the approach of a lighted match—these more volatile vapors are heavier than atmospheric air, and when suffered to escape from the cask containing them in a separate state will flow along the surface of the floor of a room, and reaching a distant fire-place will ignite, and burning backward to the reservoir will set fire to the oil from which they emanated.

Many serious accidents have occurred in this way, by the firing of a canister containing petroleum oil which has been left open, although at a distance in some cases of from 20 to 30 feet from a lighted fire. Another source of danger from the lighted oils from which the more volatile vapors arise results from the fact that these vapors when mixed with a certain portion of atmospheric air explode on the approach of a flame with extreme violence. When the proportions of vapor and air are equal no explosion takes place; but when they are in the ratio of 10 parts of the vapor in volume to 100 parts of air the explosion is most violent; when the quantity of air or of petroleum vapor is increased or diminished the explosion is less violent until one or other becomes excessive, when the vapor kindles without explosion, as is the case with ordinary street gas when issuing from the burner.

A notable case of the explosive quality of a mixture of petroleum vapor and air occured in connection with the light-house service in 1864, on Lake Michigan. The keeper in one of the light-houses of this district substituted on his own responsibility an ordinary kerosene lamp of tinned iron, for the usual lard-oil lamp. This gave a good light and required no trimming during the night; it burned well for several nights, and the keeper congratulated himself on the success of what he considered a very important experiment. Unfortunately however on the last morning that the lamp was used, he attempted to put it out in the usual way by blowing the air from his lungs down the chimney, when an explosion took place, which scattered the oil in a burning state over the deck of the tower and also on his clothes; in his fright he ran down the stairs of the tower, and had scarcely reached the ground when a violent explosion was heard above, which blew off the whole lantern and broke the lenticular apparatus.

The explanation of these two explosions is not difficult. The burning of the oil during the night left a space void of the liquid in the reservoir of the lamp, which was filled with air and vapor, which happened on this occasion to be near the explosive proportions; on blowing air down the chimney it mingled with the vapor furnishing the quantity necessary for the violent combination, and consequently the explosion occurred which broke the lamp. The second explosion was caused by the ascent of the vapor from the burning oil on the deck, and took place when the quantity exhaled amounted to a tenth part of the volume of air present. The two then suddenly rushed into combination, producing the effects that we have mentioned.

Under favorable circumstances this lamp lighted with kerosene might have burned silently for several weeks, but in accordance with the doctrine of chances, time enough being given, an explosion was inevitable. Facts of this kind in connection with the difficulty experienced in burning mineral oil in light-house lamps induced the Light-House Board to adopt lard-oil.

Various experiments have however been made from time to time by the Light-House Board with a view to the introduction of petroleum as an illuminating material, as soon as oil could be obtained in this country of a suitable character, lard-oil having advanced in price to such a degree as to render this change desirable in an economical point of view. In the mean time experiments had also been made in France and England for the purpose of introducing mineral oil as a light-house illuminant, but it was not until 1873 or 1874 that the result was entirely satisfactory.

The process of manufacturing the oil has been very much improved in this country of late years, and there are now several companies which profess to produce oil entirely safe, and otherwise suitable for light-house purposes. In view of further experiments with mineral oil, an advertisement was inserted in the papers, in 1874, requesting manufacturers to send samples of their oils to be tested at the Light-House depot at Staten Island, and in accordance with this a number of specimens were received and submitted to examination.

The first test to which the oils thus furnished were submitted was that of flashing, that is, the determination of the temperature at which the oil gives off a vapor which will flash into a flame on the approach of a small taper, or, in other words, which indicates the rise of a vapor which, mixed with atmospheric air, will tend to produce an explosion. The flashing temperature differs however from that at which the liquid takes fire as a whole. This will be understood if we suppose that two liquids have been mixed together, a light and a heavy one; the flash in this case will be due to the vapor from the lighter mixture, while the burning is due to the temperature at which the compound is fired. To make this flashing test requires considerable precautions. First, the oil to be tried is gradually heated by a spirit-lamp in a water-bath, a sensitive thermometer being suspended in the oil with the bulb slightly below the surface, the heat of the water is very slowly increased by removing from time to time the spirit-lamp from under the basin of the water-bath which contains the oil, and the point of flashing is obtained by passing over the surface of the oil a small flame until the first indication of flash is observed. The flame should not be so large as to heat the surface, and is best produced by a very small jet of gas from a glass tube drawn nearly to a point and connected with the gas pipe of the house by a tube of India-rubber, the quantity of gas being regulated by a stop-cock, so that the flame is a mere pencil of light about a quarter of an inch in length and a twentieth in diameter. The basin which contains the oil is about four inches in diameter, and is sometimes covered with a plate of thin glass, the thermometer passing through an aperture in this cover, and a larger hole being left open in the same for inserting the pencil of the flame. The basin containing the oil is sometimes left entirely open, the cover being discarded, but we do not think this as safe a method as the other. Great caution must be taken in raising the temperature very gradually, so that every part of the liquid may have the same heat and the thermometer thus truly indicate the temperature. If the rise of the temperature be very sudden, the thermometer will not respond, and the real flashing temperature will be higher than that which is indicated.

The next test is that of firing of the mass of the liquid, which is sometimes 10 or 12 degrees higher than that of the flashing temperature, but generally the two are very near each other.

The next test is the determination of the specific gravity. This was obtained by weighing, in a glass flask with a narrow neck, an equal quantity of distilled water and of the oil in question; the ratio of the two, reduced to water as unity, gave the specific gravity required. To facilitate the operation, a flask, containing just 1,000 grains of distilled water, was balanced by a permanent weight. The scales were tested by double weighing. The first series of weighing was made at the temperature of 74° F., that of the apartment in which the experiment was conducted; but oil and other substances change their bulk, and consequently their specific gravity, with a change of temperature. It is therefore necessary, in order that results may be compared, that the experiments be all made at the same temperature, or reduced to a standard temperature. The temperature formerly adopted in England for specific gravity is 62° F.; but in the case of petroleum, the temperature of 60° has been adopted in this country and England. In the first series of experiments made with the oils in question, the weighing was conducted at a temperature of 74°, as we have said, namely, that of the atmosphere at the time. A series of experiments at a lower temperature was afterward made, in order to obtain a correction by which to reduce the specific gravity first obtained to that of a temperature of 60°; but as each oil exhibits a different rate of expansion by heat, the process became very laborious. Experiments were therefore made to determine the correctness of obtaining the specific gravity of the oils by means of a hydrometer. This was found to differ from that obtained by weighing within one per cent., and was therefore concluded to be sufficiently accurate for practical purposes.

To obtain the specific gravity of the oils by means of a hydrometer, a vessel containing, say, 10 gallons of water, of a depth of about 14 inches, is provided; into this are introduced several glass cylinders containing the oil, and into these cylinders the hydrometers are plunged, the level of the oil being so far above the water that the under contact of the surface of the liquid with the scale may be observed. Before inserting the glass cylinders containing the oils into this water-bath, the liquid is brought, by mixing ice-water with it, to the temperature of 60°, at which temperature it may be kept for a long time, on account of the large quantity of the liquid and the great specific heat of the water. A change of temperature may be prevented by occasionally adding a small quantity of ice-cold water, care being taken to mingle the mixture by stirring. By this process may be obtained the specific gravity at 60° of a large number of samples in a comparatively short time. In this country and England the density or relative weight of petroleum oils is generally expressed in terms of the arbitrary scale of Beaumé's, instead of that of the specific gravity. The following table gives the equivalent of the Beaumé scale in terms of specific gravity:

Beaumé's hydrometer for liquids lighter than water.

Degrees, Beaumé.	Specific gravity.	Degrees, Beaumé.	Specific gravity.	Degrees, Beaumé.	Specific gravity.	Degrees, Beaumé.	Specific gravity.
10	1.000	23	.918	36	.849	49	.789
11	0.993	24	.913	37	.844	50	.785
12	.986	25	.907	38	.839	51	.781
13	.980	26	.901	39	.834	52	.777
14	.973	27	.896	40	.830	53	.773
15	.967	28	.890	41	.825	54	.768
16	.960	29	.885	42	.820	55	.764
17	.954	30	.880	43	.816	56	.760
18	.948	31	.874	44	.811	57	.757
19	.942	32	.869	45	.807	58	.753
20	.936	33	.864	46	.802	59	.749
21	.930	34	.859	47	.798	60	.745
22	.924	35	.854	48	.794	....	....

Another test to which the mineral oil was subjected was that of a reduction of temperature. For this purpose the samples were placed in an air-bath reduced to the temperature of 25° F. At this temperature several of the oils exhibited a thickened condition, especially those of the higher fire-test. The apparatus used for this purpose was the same as that previously described as employed in the case of lard-oil.

The next test to which the oil was subjected was that of its liquidity. This test is of some importance in regard to lamps in which the oil is pumped up by machinery, and also as to the solid matter in the oil. It therefore gives a characteristic of the oil which with others serves to determine its degree of impurity. For this purpose the same method was employed as that described for determining the liquidity of lard-oil. The liquidity exhibited by this process was very different in different oils.

All the experiments on the flowing of the oils were made at the temperature of the air, which was from 72° to 74°. In this case, as with lard, a marked difference was found in the time of flowing at different temperatures, and hence for comparison the experiments should be made at a standard temperature.

Another experiment was made to ascertain whether oils of higher flashing test gave off a vapor at the ordinary temperature of the atmosphere; for example, at about 70°. For this purpose a barometer tube of about 33 inches in length, and an interior diameter of one-half of an inch, was filled with warm mercury inverted in a basin of the same metal. The finger was then placed under the open mouth of the tube in the basin and the tube slowly inverted so as gradually to pass the vacuum through the whole length of the column, and thus to gather up any particles of air that might adhere to the side of the tube; this left a space, when the inverted tube was held vertically, of about three inches of the open end of the tube unfilled with mercury; this being refilled, the finger applied to the open end and the tube again replaced with the open end downward in the basin, the vacuum produced by this process was nearly as perfect as if the mercury had been boiled in the tube, or the latter filled with the metal in a vacuum. After this, a small quantity of oil to be tested was drawn into a small glass syringe, the curved point of which being introduced beneath the open mouth of the tube under the surface of the mercury, a small quantity of the liquid was injected into the column; this rapidly rose by its levity to the top, and there a portion of it flashed into vapor, as was evident by the depression of the mercurial column.

From this experiment it is evident that kerosene, even of a high flashing temperature, does give off vapor at ordinary temperature. It is however of so feeble tension that it does not appear capable of producing explosion unless considerable time be allowed for its accumulation. It might not be apparent that although vapor was given off in a vacuum, as in this case, it would be given off under the full pressure of the atmosphere; but it has been shown by the experiments of Mr. Dalton and others, that vapors diffuse themselves in a space filled with atmospheric air with the same elasticity and quantity as in a vacuum, time only being required to produce the effect in the atmosphere.

The oils were also examined as to the remains of any free acid which they might contain, by simply immersing in each sample a slip of litmus paper, which was suffered to remain in the liquid for 24 hours; under this test several of the samples exhibited a redness, denoting the presence of an acid which might corrode the metal of the lamps, also indicating the want of a thorough washing of the oil by an alkaline water.

Another experiment, which was exhibited to us by one of the proprietors of the oil which has a flashing test of about 140° F., consisted in lighting a lamp-wick charged with the oil and plunging it into a vessel filled with the same. The oil did not take fire, although the combustion of the wick was vigorous, and, indeed, the flame was put out when the wick was plunged beneath the surface of the oil. This experiment, which is frequently exhibited to the public, tends to give a sense of safety in the use of mineral oil which is at least in some degree fallacious. To illustrate this, the following experiments were made: First a slip of cotton cloth, about 6 inches wide and 2 feet long, was saturated with oil having a flashing test of 140°, and suspended vertically from a ring-stand; a lighted match was then applied to the middle of the length of the slip, when it instantly took fire, and burned with a fierceness which was truly appalling.

After this two pieces of cloth, one of cotton and the other of woolen, were saturated with petroleum and placed flat on two pieces of tinned iron to protect the floor. On each of these was then dropped an ordinary friction match in a state of ignition. They both broke instantly into flames, which soon entirely consumed the cloth, although but little air could obtain access to its under side, and notwithstanding the good conducting power of the tinned iron.

In a similar experiment made with the same cloth saturated with lard-oil the cloth did not take fire when a lighted match was dropped upon it. Two cotton cloths the same size were saturated, one with lard-oil, the other with petroleum, and lighted at the same time. The petroleum cloth was consumed in 1 minute 23 seconds; the lard cloth in 5 minutes.

To render these experiments more strikingly applicable to cases of accident which might occur in a light-house, a piece of cotton cloth about 2 feet square, which had been used to wipe the table on which kerosene had been spilled, was crumpled up into the condition of an ordinary dish-cloth and thrown into a corner of the room. When a lighted match was dropped on this it instantly took fire and burned with a fierceness truly alarming.

These experiments are important in establishing the fact that oils which are commonly sold as entirely free from danger are not really so. They may be safe from explosions at ordinary temperatures, and in this respect are to be preferred to the lighter oils; but when spread over a large surface they burn with greater intensity, even, as we have seen, on a surface of ice. Indeed, the results are so striking it might be well to repeat them in the presence of every light-house keeper, in order to impress him with an idea of the danger which might be apprehended in spilling the oil over his clothes or in carelessly dropping his matches on cloths which had been used in cleaning the apparatus.

Among the peculiar properties of mineral oil is its great surface-attraction or power of adhering and spreading on other surfaces, as well as ascending wicks to a much greater altitude than other oils. This property is recognized by the housekeeper who finds the exterior of the lamp covered with a film of oil shortly after it has been subjected to a thorough cleansing. It rises along the interior surface of the lamp and spreads over the outside. On account of this property it can be freely burned in lamps of which the fountain is at a considerable distance below the flame, and in which no overflow is required to produce a brilliant combustion.

A series of experiments was next made with regard to the burning qualities of mineral oils of different densities, from which it was inferred that the lighter oils in lamps of the fourth order gave a greater amount of illumination than the heavier oils, and, furthermore, that the latter charge the wick more than the former, from which it would appear that, in using mineral oil, while safety should be the prominent consideration on the one hand, in the choice of the material, regard must be had on the other to the illuminating power.

In regard to the relative photometric power of lamps of the same order charged with mineral and with lard oil, all the experiments we have yet made on this point tend to the conclusion that in smaller lamps with the more volatile oils a greater photometric power is obtained than with the same lamp when charged with lard-oil; but with the larger lamps the reverse is the case, the lard giving greater power burned in these lamps than the mineral oil.

An unexpected difficulty arose in the course of the investigations for the introduction of mineral oils on account of the form of the flame. While a lamp with a constricted chimney, like that used in the German student-lamp, gave the greatest photometrical power, it was found that the shape of the flame did not correspond with the arrangement of the lens-apparatus, a large portion of the light being thrown upward toward the sky and another toward the earth. It was only after a series of trials with chimneys of different forms and button-deflectors that a flame of the best shape was obtained. To compare these flames in actual use, they were placed in succession in a light-house, with a lens of the fourth order, and the photometrical power determined at different distances, from a mile to ten miles in extent, by interposing between the eye and the light a series of thin colored glasses, until the light was totally extinguished. It was found in these experiments that some of the flames that had an appearance of greater brilliancy near by failed to produce comparatively the same effect at a greater distance. Having settled upon the form of the flame to be used in lamps of the lower orders, arrangements have been made for the introduction of mineral oils into all the stations in the third district, at which lights of the fourth and smaller orders are at present in use. The substitution of mineral for lard oil however is a matter of no small difficulty, and requires to be made with great precaution. An entire change in all the lamps is required; the several parts of the apparatus which in the case of lard-oil lamps were united by soft solder must now be joined with spelter.

The importance of this was evinced by an accident which happened in the photometric room in the case of a lamp of the fourth order under trial; the heat unsoldered an air-tube and let down the oil from the reservoir on the flame, which produced so fierce a combustion that it would have set fire to the building had it not been of fire-proof materials.

The gradual introduction however of mineral oil will be made as rapidly as experience indicates the best and safest mode of employing it. It has already been adopted in the smaller lamps for lighting the Mississippi and its principal tributaries. The substitution however is not on account of the superior quality of this oil in comparison with lard, since we think the latter as an illuminating material is inferior to no other at present in use, but simply on account of the comparative cost of the two materials.

The comparative cost of the two materials will be definitely ascertained after we have determined the best form of lamps to be used. Experiments thus far have been principally confined to the lower orders of lamps.

A SYNOPSIS
OF THE SCIENTIFIC WRITINGS OF SIR WILLIAM HERSCHEL.

By Edward S. Holden and Charles S. Hastings.

I.—Introductory Note.

The astronomical life of Sir William Herschel covered forty-two years. During this period he published no less than sixty-nine different memoirs, which are scattered through the annual volumes of the Philosophical Transactions of the Royal Society of London from 1780 to 1818.

Two generations have passed since his death, and we have no readier means of studying his works than in the original volumes of the Transactions, now become rare and costly. Students of astronomy and physics are thus often compelled to know his writings at second-hand from text-books, and not in the vigorous and ardent style of the original. The text-books also frequently quote him incorrectly, and have thus helped to spread erroneous notions not only of what he said, but of the facts themselves.

Herschel's long life was all too short, and his assistance was too small to allow him to put even his published work into a final definite form. He has once given us a hint of what he desired, and it seems scarcely less than a duty for his successors to carry out his wishes.

At the end of his memoir of 1811, Herschel added a synopsis of its contents made paragraph by paragraph; this synopsis (which is given at pages 87–89 of this work) serves to summarize and to enforce his views, and to condense his arguments. His style lends itself to this condensation. The synopsis of 5 pages contains all the material facts of the main paper of 67 pages, and the course of the argument can be plainly followed.

In the absence of an edition of Herschel's collected works, a want whose fulfillment still seems far off, we have thought that we could hardly render a better service than to carry out for all of his writings the idea which he executed for only one. The model has been set by himself. We have simply followed this, and have given a synopsis of each of his memoirs in the Philosophical Transactions, following his own plan. The papers on astronomical subjects have been condensed by Professor Holden; those on physics by Dr. Hastings. The works of Herschel published elsewhere have not been included in the synopsis, as they are comparatively unimportant.

It is not supposed that such synopses as these will replace the original memoirs for the professional astronomer and physicist. The works of a great philosopher to be truly mastered must be studied in the form in which he gave them. Yet those who are most familiar with the originals will find the present volume most valuable.

The full subject-index will direct attention to special points. It is hoped that the work in its present form will be of service in various ways, which do not need suggestion here.

EDWARD S. HOLDEN.
CHARLES S. HASTINGS.

WASHINGTON, *October*, 1880.

II.—LIST OF THE PUBLISHED WRITINGS OF WILLIAM HERSCHEL ON ASTRONOMICAL SUBJECTS.

[IN CHRONOLOGICAL ORDER.]

[N. B. In general, translations and abstracts of these which appeared in periodicals are not noticed here. We have made exceptions in the more important cases.]

[Solution of a prize question.]
Ladies' Diary, 1799.

Astronomical observations on the periodical star in *Collo Ceti*.
Phil. Trans., 1780, p. 338.

Astronomical observations relating to the mountains of the moon.
Phil. Trans., 1780, p. 507.

Astronomical observations on the rotation of the planets round their axes, made with a view to determine whether the earth's diurnal motion is perfectly equable.
Phil. Trans., 1781, p. 115.

Account of a comet. [Dated 13th March, 1781. This was *Uranus*.]
Phil. Trans., 1781, p. 492.

On the parallax of the fixed stars.
Phil. Trans., 1782, p. 82.

Catalogue of double stars.
Phil. Trans., 1782, p. 112; translation in *Bode's Jahrbuch*, 1786, p. 187.

Description of a lamp micrometer and the method of using it.
Phil. Trans., 1782, p. 163.

A paper to obviate some doubts concerning the great magnifying powers used.
Phil. Trans., 1782, p. 173.

A letter from WILLIAM HERSCHEL, Esq., F. R. S., to Sir JOSEPH BANKS, *Bart.*, P. R. S.
Phil. Trans., 1783, p. 1.

Aus einem Schreiben des Hrn. HERSCHEL an mich [BODE], datirt London, den 13ten August, 1783.
[This is a letter forwarding HERSCHEL's memoir on the Parallax of the Fixed Stars, etc.]
Bode's Jahrbuch, 1786, p. 258.

On the diameter and magnitude of the *Georgium Sidus*, with a description of the dark and lucid disk and periphery micrometers.
Phil. Trans., 1783, p. 4.

On the proper motion of the sun and solar system, with an account of several changes that have happened among the fixed stars since the time of Mr. FLAMSTEED.
Phil. Trans., 1783, p. 247. *Bode's Jahrbuch*, 1787, p. 194, p. 224.

Astronomische Nachrichten und Entdeckungen aus einem französischen Schreiben desselben an mich [BODE], datirt Datchet nahe bey Windsor, den 18 May, 1784.
[This letter is on the subject of the use of high magnifying powers, and gives a *résumé* of his recent papers.]
Bode's Jahrbuch, 1787, p. 211.

On the remarkable appearances at the polar regions of the planet *Mars*, the inclination of its axis, the position of its poles, and its spheroidical figure; with a few hints relating to its real diameter and atmosphere.
Phil. Trans., 1784, p. 233.

Account of some observations tending to investigate the construction of the heavens.
Phil Trans., 1784, p. 437.

[*Bode's Jahrbuch*, 1788, p. 246, has a summary of this paper by Baron von ZACH. See also, *Bode's Jahrbuch*, 1794, p. 213.]

Catalogue of double stars.
Phil. Trans., 1785, p. 40.

On the construction of the heavens.
Phil. Trans., 1785, p. 213. *Bode's Jahrbuch*, 1788, p. 238. See also *same*, 1787, p. 213, and 1794, p. 213.

Aus einem Schreiben des Hrn. HERSCHEL an mich [BODE], datirt Clay Hall, nahe bey Windsor, den 20 Jul., 1785.
[This is a letter forwarding two memoirs, and giving the prices of telescopes.]
Bode's Jahrbuch, 1788, p. 254.

Catalogue of one thousand new nebulæ and clusters of stars.
Phil. Trans., 1786, p. 457. *Bode's Jahrbuch*, 1791, p. 157, and *same*, 1794, p. 213.

Investigation of the cause of that indistinctness of vision which has been ascribed to the smallness of the optic pencil.
Phil. Trans., 1786, p. 500.

Remarks on the new comet [1786, II].
Phil. Trans., 1787, p. 4.

[Letter from HERSCHEL to BODE on the discovery of two satellites to *Uranus*, dated Slough, 1787, Feb. 11.]
Bode's Jahrbuch, 1790, p. 253.

An account of the discovery of two satellites revolving round the *Georgian planet*.
Phil Trans., 1787, p. 125. *Bode's Jahrbuch*, 1791, p. 255.

An account of three volcanoes in the moon.
Phil. Trans., 1787, p. 229. *Bode's Jahrbuch*, 1791, p. 255.

Note on M. MÉCHAIN'S comet. [1787, I.] [Added to preceding paper.]
Phil. Trans., 1787, p. 232.

On the *Georgian planet* and its satellites.
Phil. Trans., 1788, p. 364. *Bode's Jahrbuch*, 1793, p. 104.

Observations on a comet [1788, II.].
Phil. Trans., 1789, p. 151.

Catalogue of a second thousand of new nebulæ and clusters of stars, with a few introductory remarks on the construction of the heavens.
Phil. Trans., 1789, p. 212. *Bode's Jahrbuch*, 1793, p. 150. Also *same*, 1794, p. 150.

Account of the discovery of a sixth and seventh satellite of the planet *Saturn*, with remarks on the construction of its ring, its atmosphere, its rotation on an axis, and its spheroidical figure.
Phil. Trans., 1790, p. 1. *Bode's Jahrbuch*, 1793, p. 239; *same*, 1796, p. 88; 1797, p. 249.

On the satellites of the planet *Saturn*, and the rotation of its ring on an axis.
Phil. Trans., 1790, p. 427.

On nebulous stars properly so called.
Phil. Trans., 1791, p. 71. *Bode's Jahrbuch*, 1801, p. 128.

On the ring of *Saturn* and the rotation of the fifth satellite upon its axis.
Phil. Trans., 1792, p. 1. *Bode's Jahrbuch*, 1796, p. 88.

Miscellaneous observations:
[Account of a comet], p. 23 [1792, I.].
[On the periodical appearance of *o Ceti*], p. 24.
[On the disappearance of the 55th *Herculis*], p. 26.
[Remarkable phenomenon in an eclipse of the moon], p. 27.
Phil. Trans., 1792, p. 23.

Observations on the planet *Venus*.
Phil. Trans., 1793, p. 201.

Observations of a quintuple belt on the planet *Saturn*.
Phil. Trans., 1794, p. 28. *Bode's Jahrbuch*, 1798, p. 90.

Account of some particulars observed during the late eclipse of the sun. [1793, September 5th.]
Phil. Trans., 1794, p. 39.

On the rotation of the planet *Saturn* upon its axis.
Phil. Trans., 1794, p. 48. *Bode's Jahrbuch*, 1798, p. 74.

On the nature and construction of the sun and fixed stars.
Phil. Trans., 1795, p. 46. *Bode's Jahrbuch*, II. Suppl. Band, p. 65.

Description of a forty-foot reflecting telescope.
Phil. Trans., 1795, p. 347. *Bode's Jahrbuch*, III. Suppl. Band, p. 238.

Additional observations on the comet. [1796, I.]
Phil. Trans., 1796, p. 131.

On the method of observing the changes that happen to the fixed stars; with some remarks on the stability of the light of our sun. To which is added a catalogue of comparative brightness for ascertaining the permanency of the luster of stars.
Phil. Trans., 1796, p. 166. *Bode's Jahrbuch*, 1809, p. 201.

On the periodical star *α Herculis;* with remarks tending to establish the rotary motion of the stars on their axes; to which is added a second catalogue of the comparative brightness of the stars.
Phil. Trans., 1796, p. 452. *Bode's Jahrbuch*, 1809, p. 201.

A third catalogue of the comparative brightness of the stars, with an introductory account of an index to Mr. FLAMSTEED's observations of the fixed stars, contained in the second volume of the Historia Cœlestis. To which are added several useful results derived from that index.
Phil. Trans., 1797, p. 293. *Bode's Jahrbuch*, 1810, p. 143.

Observations of the changeable brightness of the satellites of *Jupiter*, and of the variation in their apparent magnitudes, with a determination of the time of their rotatory motions on their axes. To which is added a measure of the diameter of the second satellite, and an estimate of the comparative size of all the four.
Phil. Trans., 1797, p. 332. *Bode's Jahrbuch*, 1801, p. 103.

On the discovery of four additional satellites of the *Georgium Sidus*. The retrograde motion of its old satellites announced, and the cause of their disappearance at certain distances from the planet explained.
Phil. Trans., 1798, p. 47. *Bode's Jahrbuch*, 1801, p. 231.

A fourth catalogue of the comparative brightness of the stars.
Phil. Trans., 1799, p. 121. *Bode's Jahrbuch*, 1810, p. 143.

On the power of penetrating into space by telescopes, with a comparative determination of the extent of that power in natural vision, and in telescopes of various sizes and constructions, illustrated by select observations.
Phil. Trans., 1800, pp. 49-85. *Bode's Jahrbuch*, 1804, p. 231.

Investigation of the powers of the prismatic colors to heat and illuminate objects, with remarks that prove the different refrangibility of radiant heat. To which is added an inquiry into the method of viewing the sun advantageously with telescopes of large apertures and high magnifying powers.
Phil. Trans., 1800, pp. 255-283. *Bode's Jahrbuch*, 1804, p. 89.

Experiments on the refrangibility of the invisible rays of the sun.
Phil. Trans., 1800, pp. 284-292. *Bode's Jahrbuch*, 1804, p. 89.

Experiments on the solar and on the terrestrial rays that occasion heat, with a comparative view of the laws by which light and heat, or rather the rays that occasion them, are subject, in order to determine whether they are the same or different.
Phil. Trans., 1800, pp. 293-326, 437-538. *Gilbert Annal.*, X. (1802), pp. 68-78; *same*, XII. (1803), pp. 521-546.

Observations tending to investigate the nature of the sun, in order to find the causes or symptoms of its variable emission of light and heat, with remarks on the use that may possibly be drawn from solar observations.
Phil. Trans., 1801, pp. 265-318. *Bode's Jahrbuch*, 1805, p. 218, and 1806, p. 113.

Ueber den 7 Nebelfleck der 1sten Classe des Herschel'schen Verzeichniss, und über *Ceres* und *Pallas*, vom Herrn Doctor HERSCHEL, aus zwey Briefen desselben.
Bode's Jahrbuch, 1805, p. 211.

Additional observations tending to investigate the symptoms of the variable emission of the light and heat of the sun, with trials to set aside darkening glasses by transmitting the solar rays through liquids, and a few remarks to remove objections that might be made against some of the arguments contained in the former paper.
Phil. Trans., 1801, pp. 354-362.

Observations on the two lately discovered celestial bodies [*Ceres and Pallas*].
Phil. Trans., 1802, pp. 213-232. *Nicholson Journal*, IV. (1808), pp. 120-130, 142-148.

Catalogue of five hundred new nebulæ, nebulous stars, planetary nebulæ, and clusters of stars, with remarks on the construction of the heavens.
Phil. Trans., 1802, pp. 477-528. *Bode's Jahrbuch*, 1807, p. 113.

Observations of the transit of *Mercury* over the sun's disk, to which is added an investigation of the causes which often prevent the proper action of mirrors.
Phil. Trans., 1803, pp. 214-232.

Account of the changes which have happened during the last twenty-five years in the relative situation of double stars, with an investigation of the cause to which they are owing.
Phil. Trans., 1803, pp. 339-382. *Bode's Jahrbuch*, 1808, pp. 154-178.

Continuation of the account of the changes that have happened in the relative situation of double stars.
Phil. Trans., 1804, pp. 353-384. *Bode's Jahrbuch*, 1808, p. 226.

Aus einem Schreiben des Herrn Doctor HERSCHEL, datirt Slough bey Windsor, den 31 May, 1804.
[Relates to his theory of the relation between the solar radiation and the price of wheat.]
Bode's Jahrbuch, 1808, p. 226.

Experiments for ascertaining how far telescopes will enable us to determine very small angles, and to distinguish the real from the spurious diameters of celestial and terrestrial objects, with an application of the results of those experiments to a

series of observations on the nature and magnitude of Mr. Harding's lately discovered star [*Juno*, (1804)].
Phil. Trans., 1805, pp. 31–70.

On the direction and velocity of the motion of the sun and solar system.
Phil. Trans., 1805, pp. 233–256. *Bode's Jahrbuch*, IV. Suppl. Band, p. 67.

Observations on the singular figure of the planet *Saturn*.
Phil. Trans., 1805, pp. 272–280. *Bode's Jahrbuch*, 1809, p. 197.

On the quantity and velocity of solar motion.
Phil. Trans., 1806, pp. 205–237. *Bode's Jahrbuch*, 1811, p. 224.

Observations and remarks on the figure, climate, and atmosphere of *Saturn* and its ring.
Phil. Trans., 1806, pp. 455–467. *Gilbert Annal.*, XXXIV. (1810), pp. 82–105. *Bode's Jahrbuch*, 1810, p. 228.

Experiments for investigating the cause of the colored concentric rings discovered by Sir I. Newton between two object glasses laid one upon another.
Phil. Trans., 1807, pp. 180–233. *Annal. de Chimie*, LXX. 1809, pp. 154–181, 293–321; *same*, LXXI. 1809, pp. 5–40.

Observations on the nature of the new celestial body [*Vesta*] discovered by Dr. Olbers, and of the comet which was expected to appear last January in its return from the sun. [1803, II.]
Phil. Trans., 1807, pp. 260–266.

Observations of a comet [1807, I.] made with a view to investigate its magnitude and the nature of its illumination, to which is added an account of a new irregularity lately perceived in the apparent figure of the planet *Saturn*.
Phil. Trans., 1803, pp. 145–163. *Gilbert Annal.*, XXXVI. (1810), pp. 389–393. *Zach Monat. Corresp.*, XX. (1809), pp. 512–514.

Continuation of experiments for investigating the cause of colored concentric rings and other appearances of a similar nature.
Phil. Trans., 1809, pp. 259–302.

Supplement to the first and second part of the paper of experiments for investigating the cause of colored concentric rings between object glasses, and other appearances of a similar nature.
Phil. Trans., 1810, pp. 149–177. *Gilbert Annal.*, XLVI., 1814, pp. 22–79.

Astronomical observations relating to the construction of the heavens, arranged for the purpose of a critical examination, the result of which appears to throw some new light upon the organization of the celestial bodies.
Phil. Trans., 1811, pp. 269–336. *Journ. de Phys.*, LXXV., 1812, pp. 121–167.

Observations of a comet, with remarks on the construction of its different parts. [1811, I.]
Phil. Trans., 1812, pp. 115–143. *Journ. de Phys.*, LXXVII., 1813, pp. 125–135. *Zach Monat. Corresp.*, XXVIII., 1813, pp. 455–469, 558–568. *Bode's Jahrbuch*, 1816, p. 185.

Observations of a second comet, with remarks on its construction. [1811, II.]
Phil. Trans., 1812, pp. 229–237. *Nicholson Journ.*, XXXV., 1813, pp. 193–199. *Bode's Jahrbuch*, 1816, p. 203.

Astronomical observations relating to the sidereal part of the heavens, and its connection with the nebulous part, arranged for the purpose of a critical examination.
Phil. Trans, 1814, pp. 248–284. *Bode's Jahrbuch*, 1818, pp. 97–118.

A series of observations of the satellites of the *Georgian Planet*, including a passage through the node of their orbits, with an introductory account of the telescopic apparatus that has been used on this occasion, and a final exposition of some calculated particulars deduced from the observations.
Phil. Trans., 1815, pp. 293–362. *Bode's Jahrbuch*, 1819, pp. 232–242.

Astronomical observations and experiments tending to investigate the local arrangement of the celestial bodies in space, and to determine the extent and condition of the Milky Way.

Phil. Trans., 1817, pp. 302–331. *Bode's Jahrbuch*, 1821, p. 149.

Astronomical observations and experiments selected for the purpose of ascertaining the relative distances of clusters of stars, and of investigating how far the power of our telescopes may be expected to reach into space, when directed to ambiguous celestial objects.

Phil. Trans., 1818, pp. 429–470.

On the places of one hundred and forty-five new double stars (1821).

Mem. Roy. Ast. Soc., I., 1822, pp. 166–181.

III.—LIST OF WORKS RELATING TO THE LIFE AND WRITINGS OF WILLIAM HERSCHEL.

[ARRANGED ALPHABETICALLY BY AUTHORS.]

[N. B. In general, the notices of his life to be found in encyclopædias of biography, etc., are not included here.]

Arago (F.)

Analyse de la vie et des travaux de Sir WILLIAM HERSCHEL [from *Annuaire du Bureau des Longitudes*, 1842]. Paris, 1843. 18mo.

[See also the *Annuaire* for 1834, for an account of HERSCHEL'S work on double stars.]

Arago (F.)

Biographies of Distinguished Scientific Men. Translated by Admiral W. H. SMYTH, Rev. B. POWELL, and ROBERT GRANT, Esq. HERSCHEL.
First series, p. 258. Boston, 1859. 8vo.

Arago (F.)

HERSCHEL. [Translated from the French.]
Smithsonian Report. 1870, p. 197. 8vo.

Auwers (A.)

WILLIAM HERSCHEL'S Verzeichnisse von Nebelflecken und Sternhaufen bearbeitet von A. AUWERS.
From the *Königsberg Observations*. 1862. Folio.

Bessel (F. W.)

Sir WILLIAM HERSCHEL. [From the *Königsberger Allgemeine Zeitung*, 1, 1843, No. 37, *et seq.*, reprinted in his] *Abhandlungen*, vol. iii., p. 468. Leipzig, 1876. 4to.

Bruhns (C.)

KAROLINE LUCRETIA HERSCHEL, aus der *Allgem. Deutschen Biographie.* 1877, 8vo.

D'Arrest (H. L.)

Verzeichniss von Sir WILLIAM HERSCHEL'S Nebelflecken *erster* und *vierter* Classe, aus den Beobachtungen berechnet und auf 1850 reducirt.
Abhandlungen d. Math. Phys. Classe der K. Sächs. Gesell. d. Wissenschaften Band iii [1857] p, 359.

Dunkin (E.)

Obituary Notices of Astronomers, p. 86.
Sir WILLIAM HERSCHEL, K. C. H., F. R. S., 1738, 1822.
London, 1879. 12mo.

Fétis (F. J.)

Biographie universelle des musiciens [article, HERSCHEL.]
Paris, 1835-37. 8vo.

Forbes (J. D.)

Sir WILLIAM HERSCHEL [being § 2 of Dissertation vi.]
Encyclopædia Britannica, eighth edition. Vol. I, *Dissertations*, p. 838.

Fourier (J.)

Éloge historique de Sir WILLIAM HERSCHEL, prononcé dans la séance publique de l'Académie royale des sciences le 7 Juin, 1824.
Histoire de l'Académie Royale des Sciences de l'Institut de France, tome vi., *année* 1823, p. lxi.

Harding (C. L.)

Des Herrn Dr. HERSCHEL's Untersuchungen über die Natur der Sonnenstrahlen, aus dem englischen übersetzt. Erstes Heft. [Translations from *Phil. Trans.*, 1800.] Celle, 1801. 16mo.

Herschel (Carolina.)

An Account of a new Comet. [1786, II.]
Phil. Trans., 1787, vol. 77, p. 1.

Herschel (Carolina.)

An Account of the Discovery of a Comet. [1793, I.]
Phil. Trans., 1794, vol. 84, p. 1.

Herschel (Carolina.)

An Account of the Discovery of a Comet. [1795, II.]
Phil. Trans., 1796, vol. 86, p. 131.

Herschel (Carolina.)

Catalogue of Stars taken from FLAMSTEED's observations contained in the second volume of his Historia Cælestis, and not inserted in the British Catalogue; to which is added a collection of errata which should be noticed in the same volume; with remarks by W. HERSCHEL. London, 1798. Folio.

Herschel (Carolina.)

Verzeichniss von 74 Sternen FLAMSTEEDS von denen keine Beobachtungen in der *Hist. Cœl. Brit.* vorkommen.
Bode's Jahrbuch, 1806, p. 255.

[Herschel (Carolina.)]

[Notice of her life.]
Monthly Notices Roy. Ast. Soc. vol. 8, p. 64; *also Memoirs Roy. Ast. Soc.*, vol. 17, p. 120.

Herschel (Carolina.)

Memoir and Correspondence of CAROLINE HERSCHEL. By Mrs. JOHN HERSCHEL. With portraits. London, 1876. 12mo.

Herschel (J. F. W.)

Article *Telescope*, in Encyclopædia Britannica, eighth edition. [This article (illustrated) gives most of the important features of Sir WILLIAM HERSCHEL's manner of grinding and polishing specula.]

Herschel (J. F. W)

Catalogue of Nebulæ and Clusters of Stars. [General and systematic reduction of all Sir W. HERSCHEL's observations brought into connection with all other similar ones.]
Phil. Trans., 1864. Page 1. 4to.

Herschel (J. F. W.)

A synopsis of all Sir WILLIAM HERSCHEL's micrometrical measurements, etc., of Double Stars, together with a Catalogue of those Stars . . . . for 1880.
Mem. Roy. Ast. Soc., vol. xxxv, p. 21. London, 1867. 4to.

Herschel (J. F. W.)

Additional Identifications of Double Stars in the Synoptic Catalogues of Sir WILLIAM HERSCHEL'S Micrometrical Measurements, etc.

Monthly Notices Roy. Ast. Soc., vol. xxviii, p. 151. London, 1868. 8vo.

Herschel (Mrs. John,)

Memoir and Correspondence of CAROLINE HERSCHEL. With portraits. London, 1876. 12mo.

Herschel (W.)

[Solution of a prize question.]

Ladies' Diary, 1779.

Herschel (W.)

The favorite Eccho Catch . . . and the preceding Glee [by S. LEACH]. To which is added the . . . Catch Sung by Three Old Women . . . in the Pantomime called "The Genius of Nonsense" [by H. HARRINGTON].

London, 1780 (?) Obl. folio.

Herschel (W.)

Göttingen Magazin der Wissenchaften und Literatur (1783), vol. iii, p. 4. LICHTENBERG AND FORSTER, Editors.

[Letter from HERSCHEL, giving a brief account of his life.]

Herschel (W.)

I. *Manuscripts in possession of the Royal Society.*

1. A series of register sheets in which are entered up *all* the observations of *each* nebula, copied *verbatim* from the sweeps. 2. A similar set of register sheets for MESSIER'S nebulæ. 3. A general index of the 2,508 nebulæ of W. HERSCHEL; given the class and number, to find the general number. 4. An index list; given the general number, to find the class and number. 5. A more complete list, like 4. 6. A manuscript catalogue of all the nebulæ and clusters, reduced to 1800 and arranged in zones of 1° in polar distance; by Miss CAROLINA HERSCHEL. 7. The original sweeps with the 20-foot reflector at Slough, in three small quarto and four folio vols. of MSS.

II. *Manuscripts in possession of the Royal Astronomical Society.*

This library contains "the whole series of autograph observations of each double star [observed by HERSCHEL], brought together on separate sheets, by Sir WILLIAM HERSCHEL and Miss CAROLINA HERSCHEL."

[Herschel (W.)]

Some account of the life and writings of WILLIAM HERSCHEL, Esq. [With a portrait.]

The *European Magazine and London Review* for January, 1785. 8vo.

[Herschel (W.)]

Edinburgh Review, vol. i, p. 426.

[A review of HERSCHEL'S memoir "Observations on the two lately discovered bodies," from *Phil. Trans.*, 1802.]

[Herschel (W.)]

"Sir WILLIAM HERSCHEL, from a London paper."

[This is a short obituary notice "furnished by a gentleman well acquainted with Sir WILLIAM and his family, and its accuracy may be relied on."]

Niles' Register, vol. 23, p. 154, November 9, 1822. 8vo.

[Herschel (W.)]

Obituary: Sir WILLIAM HERSCHEL, Knt., LL.D., F.R.S.

The Gentleman's Magazine and Historical Chronicle, vol. xcii, 1822, p. 274. 8vo.

[Herschel (W.)]

Annual Register, 1822, p. 289. 8vo.

[Herschel (W.)]
W. HERSCHEL'S Sämmtliche Schriften. Erster Band. Ueber den Bau des Himmels. Mit 10 Kupfertafeln. [Edited by J. W. PFAFF. A second edition was published in 1850.] Dresden and Leipzig, 1828. 8vo.

[Herschel (W.)]
New York Mirror, vol. vi, 1829–'30, p. 388.

[Herschel (W.)]
Living Age, vol. ii, p. 125, (1844). 8vo. [Reprinted from *Chambers' Journal.*]

[Herschel (W.)]
Foreign Quarterly Review, vol. 31, p. 438. 8vo.
[Review of ARAGO'S "Analyse de la Vie et des Travaux de Sir WILLIAM HERSCHEL."]

[Herschel (W.)]
ARAGO'S Life of HERSCHEL.
Eclectic Museum, vol ii, p. 556. [Reprinted from the *Foreign Quarterly Review*, vol. 31.]

Holden (E. S.)
On the inner satellites of *Uranus*. [Reduction of Sir WILLIAM HERSCHEL'S observations.]
Proceedings Amer. Assn. Adv. Science, August, 1874, p. 49. 8vo.

Holden (E. S.)
Index Catalogue of Books and Memoirs relative to nebulæ, clusters, etc. *Smithsonian Miscellaneous Collections*, No. 311, pp. 19–38. [Abstracts of Sir WILLIAM HERSCHEL'S memoirs (on nebulæ) in the *Philosophical Transactions.*]
Washington, 1877. 8vo.

Holden (E. S.)
Sir WILLIAM HERSCHEL, his life and works. New York, 1881. 12 mo. (with a portrait.)

Krafft (J. G. F.)
Kurze Nachricht von dem berühmten Astronomen HERSCHEL und einigen seiner Entdeckungen.
Bayreuth, 1787. 8vo.

Peirce (C. S.)
Photometric Researches. [A reduction of HERSCHEL'S observations on the comparative brightness of the stars.] *Annals Harvard College Observatory*, vol. ix. Leipzig, 1878. 4to.

Sommer (G. M.)
WILLIAM HERSCHEL * * * ueber den Bau des Himmels; drei abhandlungen aus dem englischen uebersetzt, nebst einem authentischen Auszug aus KANTS allgemeiner Naturgeschichte und Theorie des Himmels.
Königsberg, 1791. 8vo.

Struve (W.)
Études d'astronomie stellaire. Sur la voie lactée et sur la distance des étoiles fixes. [P. 24 *et seq.* contains an elaborate review of the construction of the heavens according to HERSCHEL.] St. Petersburg, 1847. 8vo.

Wolf (R,)
WILLIAM HERSCHEL. Zurich, 1867. 8vo.

Zach (F. von.)
Dr. WILLIAM HERSCHEL [translated from *Public Characters* and printed in ZACH'S *Monatlich Correspondenz*, 1802, part I, p. 70, *et seq.*]

IV.—LIST OF THE PUBLISHED PORTRAITS OF WILLIAM HERSCHEL.

Artist, MME. DUPIERY. *Engraver,* THÖNERT. 8vo. Early portrait. Some copies in red. Profile.

Artist, F. REHBURG. *Engraver,* F. W. BOLLINGER. 8vo. Late portrait.

Artist, ——? *Engraver,* C. WESTERMAYR. 8vo. Medallion.

Artist, C. BRAND. *Engraver,* ——? 8vo. Lithograph.

Artist, ——? *Engraver,* J. SEWELL. 8vo. Profile, 1785.

Artist, ——? *Engraver,* ——? 8vo. Profile.

Artist, F. BONNEVILLE. *Engraver,* F. BONNEVILLE. 8vo. Profile.

Artist, J. RUSSELL, R. A. *Engraver,* E. SCRIVEN. 8vo. Engraved from a crayon in the possession of his son, and published by the S. D. U. K. in the *Gallery of Portraits,* vol. 5.

Artist, ——? *Engraver,* ——? 8vo. *European Magazine,* Jan., 1785. This is a bust in profile showing the left side of the face.

Artist, ——? *Engraver,* THOMSON. 8vo. Published by Caxton, 1823. This must have been engraved before 1816, since the legend is WILLIAM HERSCHEL, LL. D., F. R. S.

Artist, Lady GORDON. From the painting by ABBOTT in the National Portrait Gallery. *Engraver,* JOSEPH BROWN. 8vo. Published in memoir of CAROLINE HERSCHEL. This is of the date 1788, or thereabouts.

Artist, ——? *Engraver,* C. MÜLLER. 4to. Medallion. 1785 (?

Artist, ——? *Engraver,* H. PINHAS. 4to. Legend in Russian.

Artist, BAISCH. *Engraver,* ——? 4to. Lithograph.

Artist, H. GRÉVEDON. *Engraver,* ——? Fol. Lithograph.

Artist, ——? *Engraver,* F. MÜLLER. Fol.

Artist, ABBOTT. *Engraver,* RYDER. Fol. 1788.

Artist, J. BOILLY. *Engraver,* ——? Fol. 1822. Lithograph.

Artist, ——? *Engraver,* J. GODBY. Fol.

R. W. S. LUTWIDGE, Esq., F. R. A. S., has an original seal with a head of Sir WILLIAM HERSCHEL, which is shown on the title-page of this work. A cut of it has been courteously furnished me by JOHN BROWNING, Esq., F. R. A. S., etc.

In 1787 a bust of HERSCHEL was made by LOCKIE for Sir WILLIAM WATSON.

A picture of HERSCHEL was painted by Mr. ARTAUD about the beginning of 1819. A portrait of HERSCHEL by ABBOTT is in the National Portrait Gallery, London. There are no doubt many other paintings in England, though I can find notices of these only. The Royal Society of London has nearly a hundred portraits of its most distinguished members, but owns none of Sir WILLIAM HERSCHEL.

V.—SYNOPSIS OF THE SCIENTIFIC WRITINGS OF WILLIAM HERSCHEL.

Abstracts of William Herschel's Memoirs in the Philosophical Transactions of the Royal Society of London.

A.D.	*Vol.*	*P.*	
1780	70	338	*Astronomical observations on the Periodical Star in Collo Ceti.* By Mr. WILLIAM HERSCHEL, of Bath, communicated by Dr. WATSON, jr., of Bath, F. R. S. Read May 11, 1780.
		338	This star is *o Ceti*, and was first observed by DAVID FABRICIUS, August 13, 1596.
		338	HERSCHEL'S observations begin 1777, October 20.
		339	*β Ceti* is brighter than *α*, which indicates a change since BAYER.
		340	2′ (of arc) "is hardly sufficiently large to distinguish a square from a circle."
		341	"The periodical star preceded a very obscure telescopic star" 1′ 45″.16.

Herschel, W.: SYNOPSIS OF THE WRITINGS OF—Continued.

A. D. *Vol.* *P.*

1780 70 341 This measure repeated 1′ 50″.47.

342 This measure repeated 1′ 53″.437.

342 This measure repeated 1′ 50″.625.

342 This measure repeated 1′ 45″.937.

343 "MAUPERTUIS accounts for the periodical appearances of changeable stars by supposing that they may be of a flat form, like Saturn's ring, which becomes invisible when the edge is presented to us."

343 This star "appeared always full and round when I viewed it with a telescope"; this is not necessarily opposed to MAUPERTUIS' explanation on account of the aberrations.

344 "KEILL says 'it is probable that the greatest part of this star is covered with spots and dark bodies, some part thereof remaining lucid; and while it turns about its axis, does sometimes shew its bright part, sometimes it turns its dark side to us, etc.'"

1780 70 507 *Astronomical Observations relating to the mountains of the Moon.* By Mr. HERSCHEL, of Bath. Communicated by Dr. WATSON, jun., of Bath, F. R. S. Read May 11, 1780.

508 The method used by HEVELIUS and others to find the height of a mountain in the Moon explained. Figure 1.

509–512 Quotations from GALILEO, HEVELIUS, LALANDE, FERGUSON, and KEILL.

512 Explanation of the method used by HERSCHEL.

513 The instrument used was a Newtonian reflector 6 feet 8 inches focal length, (usual), magnifying power 222 diameters, the aperture used was four inches. "I believe that for distinctness of vision this instrument is perhaps equal to any that was ever made."

514 Observations in detail from November 30, 1779, to February 19, 1780.

517 "From these observations I believe it is evident that the height of the lunar mountains in general is greatly overrated; and that when we have excepted a few, the generality do not exceed half a mile in their perpendicular elevation."

518 "One caution, I would beg leave to mention to those who may use the excellent 3½ feet refractors of Mr. DOLLOND. The admirable quantity of light, which on most occasions is so desirable, will probably give the measure of the projection somewhat larger than the true, if not guarded against by proper limitations placed before the object-glass."

519 Continuation of the same observations 1780, March 11—March 16.

522 Additional memoranda of the manner in which Mr. HERSCHEL made his observations taken from a letter of his to the Astronomer Royal.

Plate XI contains five figures (diagrams) to illustrate the methods of observation.

1781 71 115 *Astronomical Observations on the rotation of the planets round their axes, made with a view to determine whether the earth's diurnal motion is perfectly equable.* In a letter from Mr. WILLIAM HERSCHEL, of Bath, to WILLIAM WATSON, M. D., F. R. S. Read January 11, 1781.

115 While every one of the motions of the earth that arise from the actions of the sun, moon, and planets, etc., have been investigated by astronomers, there is one motion which has hitherto escaped the scrutiny of observers—the diurnal rotation round its axis.

116 The reason why this has not been looked into is probably the difficulty of finding a proper standard to measure it by; since it is itself the standard by which we measure all the other motions.

Herschel, W.: SYNOPSIS OF THE WRITINGS OF—Continued.

A. D. *Vol.* *P.*

1781 71 116 We have no cause to suspect any very material periodical inequality.

116 Aberration would forever have remained a secret to us if it had not been found out by other methods than that of time-keepers.

117 No time-keeper will measure such equal portions of time as we require to compare the diurnal motion of the earth to.

117 The diurnal rotation of the earth being at least tolerably equable, that of the other planets is likely to be also; and this suggested the thought of estimating the diurnal motion of one planet very exactly by that of another, making each the standard of the other.

117 Such a test might detect a retardation occasioned by some resistance of a very subtle medium in which the heavenly bodies perhaps move, or any acceleration from some cause or other.

117 The common account of the diurnal rotations of the planets was much too inaccurate for this critical purpose, and new observations were required.

118 *Mars* was the most suitable planet for the purpose, as the dark spots on *Jupiter* change their places. These may be supposed to be large black congeries of vapors and clouds swimming in the atmosphere of *Jupiter*.

118 The bright spots also, though they may adhere firmly to the body of *Jupiter*, may undergo some change of situation by being differently covered or uncovered, on one side or the other, by alterations in the belts.

118 The same bright spot, not suspected of any change of situation, gave by one set of observations $9^h\,51^m\,45^s.6$, and by another set $9^h\,50^m\,48^s$.

118 The analogy of the trade-winds on the earth may account for all the irregularities of *Jupiter's* revolutions deduced from spots on the disc

119 If, with CASSINI, we suppose his rotation-time to be $9^h\,56^m$, then some spots that I have observed must have been carried through about 60° of *Jupiter's* equator in 22 of his days. This very large velocity in the clouds is not unparalleled by what has happened in our own atmosphere.

119 The spots on *Mars* are of a different nature. Their constant and determined shape, as well as remarkable color, show them to be permanent, and fastened to the body of the planet.

119 Suppose that we can determine whether a spot on the disc of *Mars* is or is not in the line which joins the center of the earth and the center of that planet to half an hour's time with certainty, in this case we shall in 30 days have the revolution true to a minute, and in three months to 20^s. An interval of about 780 days (the next opposition) will give the diurnal motion true to about 2^s, etc.

120 Had such observations as these been made 2000 or 200 years ago, we might now, by repeating them, most probably become acquainted with some curious minute changes that may have hitherto passed unnoticed.

120 The difference between the polar and equatorial diameters of the earth is by actual measurement 36.9 miles, by theory 33.8, from which it should seem probable that when the earth assumed the present form the diurnal rotation was somewhat quicker than it is at present. But I would not lay much stress upon this argument.

121 The telescopes used were of my own construction, and are a 20-feet Newtonian reflector, a 10-feet reflector of the same form, and the 7-feet reflector already mentioned (*Phil. Trans.* 1780, p. 513).

121 The time was determined with a brass quadrant of 2 feet radius, carrying a telescope magnifying 40 diameters.

Herschel, W.: SYNOPSIS OF THE WRITINGS OF—Continued.

A. D. *Vol.* *P.*

1781 71 121 Two very good clocks were used; one having a deal pendulum rod and one a compounded one of brass and iron, both having a proper contrivance not to stop when winding up. The rate of going of my clocks I determined by the transit of stars.

121 Observations on *Jupiter* in the year 1778. February 24—April 12. (See Plate V, Figs. 1 to 12, drawings of *Jupiter*.)

123 Observations on *Jupiter* in 1779. April 14—April 23. See Plate V, Fig. 13 [misprinted 18].

124 Comparing the observations two and two the following times of one synodical revolution:

$9^h\ 54^m\ 56^s.4$ from an interval of 17 revolutions;
$9^h\ 55^m\ 20^s$ from an interval of 12 revolutions;
$9^h\ 55^m\ 24^s$ from an interval of 15 revolutions;
$9^h\ 55^m\ 4^s.6$ from an interval of 41 revolutions;
$9^h\ 55^m\ 40^s$ from an interval of 1 revolution;
$9^h\ 54^m\ 58^s.2$ from an interval of 29 revolutions;
$9^h\ 54^m\ 53^s.4$ from an interval of 26 revolutions;
$9^h\ 51^m\ 35^s$ from an interval of 12 revolutions;
$9^h\ 51^m\ 45^s.6$ from an interval of 12 revolutions;
$9^h\ 50^m\ 48^s$ from an interval of 10 revolutions;
$9^h\ 51^m\ 19^s.4$ from an interval of 22 revolutions; combining the two preceding.

126 These several results are so various that it is evident that *Jupiter* is not a proper planet for this critical purpose. This great variety cannot proceed from inaccuracy in the observations; for, in my opinion, it is not possible to make a mistake in the position of a spot which shall amount to 5 minutes of time, as was proved by the observation of April 23, 1779.

126 The synodical revolutions have not been reduced to sidereal ones.

126 By a comparison of the different periods it appears that a spot gradually performs its revolutions in less time than it did at first. Examples of this are given.

126 This is consonant with the theory of equatorial winds.

127 Observations on *Mars* in the year 1777. (April 8—April 27.) See Plate VI, Figs. 14—19, drawings of *Mars*.

128 Observations on *Mars* in the year 1779. (May 9—June 17.) Figs. 20—23, drawings of *Mars*.

130 Comparing the observations of 1779 two and two the periods are:

$24^h\ 38^m\ 1^s.5$ from an interval of 2 revolutions;
$24^h\ 34^m\ 1^s.5$ from an interval of 2 revolutions;
$24^h\ 38^m\ 5^s.9$ from an interval of 36 revolutions;
$24^h\ 38^m\ 5^s.4$ from an interval of 38 revolutions;
$24^h\ 38^m\ 20^s.3$ from an interval of 34 revolutions.

131 Method of reducing synodic revolutions to sidereal (see Fig. 24, diagram).

133 The sidereal periods from observations of 1777 and 1779 are:

$24^h\ 39^m\ 23^s.03$ from an interval of 768 revolutions;
$24^h\ 39^m\ 18^s.94$ from an interval of 763 revolutions;
$24^h\ 39^m\ 23^s.04$ from an interval of 763 revolutions.

134 $24^h\ 39^m\ 21^s.67$ the adopted sidereal revolution of *Mars* on his axis.
[PROCTOR'S value, $24^h\ 37^m\ 22^s.715$.]

Herschel, W.: Synopsis of the Writings of—Continued.

A. D. *Vol.* *P.*

1781 71 134 Consideration of three sources of possible error: I, a mistake in the whole number of revolutions; II, a mistake in estimating the time when a spot comes to a certain place; III, the [determination of the] time may be in error.

135 A mistake in the whole revolutions would have made an error of 1^h in the concluded rotation time, and the agreement of the three results shows that no such mistake has been made.

The second cause of error is of some force. An error of 10^m is not likely, as is shown by the results of some experiments. These were made by placing dots within circles drawn on paper, the (eccentric) positions of the dots corresponding to positions of a spot on *Mars*, 10, 15, and 20 minutes distant from his centre. These were shown to various persons, who all agreed in locating the dots on the proper side of the centre.

136 The time was satisfactorily determined in 1779, but in 1777 not so much so, as I was then not provided with an altitude instrument.

136 Allowing for this, the uncertainty of the deduced rotation period is estimated at not above $2^s.34$.

137 An ephemeris of the times of appearances of a dark spot on *Mars* has been calculated for 1781 [and is given, p. 138].

138 Observation of the beginning and ending of the *solar eclipse* of June 24, 1778.

1781 71 492 *Account of a Comet.* [The planet *Uranus.*] By Mr. Herschel, F. R. S., communicated by Dr. Watson, jun., of Bath, F. R. S. Read April 26, 1781.

492 "On Tuesday, March 13 [1781], between 10 and 11 in the evening, while I was examining the small stars in the neighborhood of *H Geminorum*, I perceived one that appeared visibly larger than the rest. Being struck with its uncommon magnitude, I compared it to *H Geminorum* and the small star in the quartile between *Auriga* and *Gemini*, and finding it so much larger than either of them, suspected it to be a comet."

492 The magnifying power used "when I first saw the comet was 227." By applying higher powers (460 and 932) the diameter of the comet increased in proportion to the power, while the diameters of the stars to which I compared it were not increased in the same ratio.

494 Measures of the comet's diameter (March 17, April 18); the measures vary from $3'' 53'''$ to $5'' 20'''$.

494 "By experience I have found that the aberration or indistinctness occasioned by magnifying much, provided the object be still left sufficiently distinct, is rather to be put up with than the power to be reduced when the angles to be measured are extremely small."

496 Distance of the comet from certain telescopic stars. [See diagrams of these stars and the comet in Plate XXIV, 1–6.]

497 Position-angles.

498 Miscellaneous observations and remarks.

March 19: It moves according to the order of the signs, and its orbit declines but very little from the ecliptic.

April 6: The comet appeared perfectly sharp at the edges and extremely well defined.

498 Remarks on the path of the comet.

499 The field of view was bright, the micrometer-thread black.

Herschel, W.: SYNOPSIS OF THE WRITINGS OF—Continued.

A. D.	*Vol.*	*P.*	
1781	71	500	Description of a Micrometer for taking the angle of position. (See PLATE XXVI, figs. 1, 2, 3, 4.) This is the modern form.
1782	72	82	*On the Parallax of the Fixed Stars*, by Mr. HERSCHEL, F. R. S.; communicated by Sir JOSEPH BANKS, Bart., P. R. S. Read December 6, 1781.
		82	The nearest of the fixed stars cannot be less than 40,000 diameters of the whole annual orbit of the earth distant from us.
		82	As we cannot enlarge this base, we can only endeavor to improve the instruments by which we measure the parallax.
		82	To measure small angles with accuracy two things are necessary: 1st, that the instrument used for the purpose should be divided with sufficient exactness; and 2d, that the telescope should have an adequate power and distinctness.
		83	The first condition is (now) practically fulfilled. The chief difficulty is in the optical part. To see 1″ with precision requires a telescope of very great perfection.
		83	Even supposing the parallaxes of stars not to amount to single seconds, or even thirds [$\frac{1}{60}''$], the observations necessary to show this would still have value.
		84	The next step necessary to consider in this undertaking was the manner of putting it into execution.
		84	The method proposed by GALILEO, and attempted by HOOK, FLAMSTEED, MOLINEUX, and BRADLEY, of measuring zenith distances of stars which pass close to the zenith, though it failed with regard to parallax, has been productive of the most noble discoveries of another nature.
		84	BRADLEY (in *Phil. Trans.*, No. 406, p. 637) concludes that the parallax of *γ Draconis*, or of *η Ursæ Majoris*, "is not so great as one single second."
		85	*γ Draconis* is a bright third magnitude, and the conclusion that several authors have reached, that the parallaxes of stars in general do not exceed 1″, does not appear to me to follow from the observations.
			For aught we know to the contrary, the stars of the first magnitude may still have a parallax of several seconds.
		86	The method of zenith distances labors under the following considerable difficulties: In the first place, the refractions; 2d, the change of position of the earth's axis, arising from nutation, precession, and other causes, is not completely settled; 3d, the aberration, though best known of all, may also be liable to some small errors.
		87	I shall now deliver the method I have taken and show that it is free from every error to which the former is liable, and is still capable of every improvement the telescope and mechanism of micrometers can furnish.
		87	Let O and E (fig. 1) be two opposite points of the earth's orbit, in the same plane with two stars, *a* and *b*, of unequal magnitude. Let the angle *a*O*b* be observed when the earth is at O, and *a*E*b* when the earth is at E. From the difference of these angles we may calculate the parallax of the stars. These two stars ought to be as near each other as possible, and also differ as much in magnitude as we can find them.

Herschel, W.: Synopsis of the Writings of—Continued.

A.D.	*Vol.*	*P.*	
1782	72	88	Galileo was the first who suggested this method; but he does not observe that the stars should be so near to each other as thereby to preclude the influence of every cause of error.
		88	This method has been also mentioned by other authors. Dr. Long observed *γ Arietis*, *α Geminorum*, *θ Orionis*, and *γ Virginis*, and "was persuaded that they would be found always to remain the same."
		88	Every one of these stars are [*sic*] totally improper for the purpose; for the stars in *γ Arietis* are near 10″ distant, and, moreover, equal in magnitude. In *α Geminorum* the stars are near enough, but do not sufficiently differ in magnitude to shew any parallax. The stars in the Nebula of *Orion*, on account of their extreme smallness of distance, are still more improper than any; and those of *γ Virginis* are equal in magnitude.
		88	The magnifying powers used by Galileo and Long were too small, not above 60 or 70.
		89	From a great number of observations which I have already made on several double stars, especially *ε Boötis*, it appears that we can affirm the annual parallax to be exceedingly small indeed; and that there is a great probability of succeeding still farther in this laborious but delightful research, so as to be able at last to say, not only how much the annual parallax *is not* but how much it really *is*.
		90	Discussion of the effect of refraction on such measures.
		91	Too much has hitherto been taken for granted in optics. Why the method (of experiment) should not be more pursued in the art of seeing does not appear.
		92	We are told that we gain nothing by magnifying *too much*. I grant it; but shall never believe I magnify too much till by experience I find that I can see better with a lower power.
		92	Telescopes will in general discover more small stars the more light they collect, yet with a power of 227 I cannot see the small star following *o Aquilæ*, when by the same telescope it appears very plainly with the power of 460. Now in the latter case the light is less than the fourth part of the former.
		93	Other similar cases noted and the names of the small stars given.
		93	Great power may be favorable in cases where two stars are close together. Figs. 2–5 show *α Lyræ* with powers 460, 2,010, 3,168, and 6,450 with my Newtonian reflector.
		94	A new micrometer has been invented, which will be described in a subsequent paper.
		94	The powers that may be used upon various double stars are different according to their relative magnitudes; *ε Boötis*, for example, will not bear the same power as *α Geminorum*.
		95	I have always found a single eye-glass had much the superiority over a double eye-glass, both in light and distinctness. I would except those cases where a large field is necessary.
		95	If we would distinctly perceive and measure extremely small quantities, such as a tenth of a second, it appears that when we use a power of 460 this tenth of a second will be no more in appearance than 46″, and even with a power of 1,500 will be but 2′ 30″, which is a quantity not much more than sufficient to judge well of objects and to distinguish them from each other, such as a circle from a square, triangle, or polygon.

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1782	72	96	[Foot-note.] By a set of experiments made in 1774 I found that I could discover or perceive a bright object, such as white paper, against the skylight when it subtended an angle of 35″, but could only distinguish it to be a circle, and no other figure, when it appeared under an angle of 2′ 24″.
		96	We must look for distinctness in the perfection of the object speculum of a telescope, and if we can make the first image in the focus of a speculum almost as perfect as the real object, what should hinder our magnifying but loss of light?
		96	The stars having light sufficient, I see no reason why we should limit the powers of our instruments by any theory.
		97	In this research it became necessary to look out for proper stars. I took some pains to find out what double stars had been recorded by astronomers, but my situation permitted me not to consult extensive libraries. Nor indeed was it very material; for, as I intended to view the heavens myself, Nature, that great volume appeared to me to contain the best catalogue upon this occasion.
		97–8	Enumeration of a few double stars which were known when this research began.
		98	If I should mention any observations that are difficult to be verified I beg the indulgence of observers. I hope it will be found that I have sufficiently guarded against optical illusions, and that I have all along had truth and reality in view as the sole object of my endeavors.
		99	In the observations of the *distances* of double stars, I have used two ways. Those which are extremely near to each other may be estimated by the eye in measures of their own apparent diameters. Such estimations are accurate, as is shown by experiments with circles drawn on paper near together.
		100	I have divided double stars into several classes. Class I contains the most difficult.
		100	These being the most delicate objects it will not be amiss to go gradually through a few preparatory steps of vision.
		100	Examples of such preparatory steps given.
		101	These double stars are a most excellent way of trying a telescope.
		101	Class II of double stars contains all those that are proper for estimations by the eye, or very delicate measures of the micrometer. See fig. 6 of α *Geminorum*.
		102	Estimations made with one telescope cannot be compared to those made with another.
		102	Whatever may be the cause of the apparent diameters of the stars, they are certainly not of equal magnitude with the same powers in different telescopes, nor of proportional magnitude with different powers of the same telescope.
		102	Class III contains all double stars more than 5″ and less than 15″ asunder.
		103	Class IV contains double stars 15″ to 30″ asunder.
			Class V contains double stars 30″ to 60″ asunder.
			Class VI contains double stars 60″ and over asunder.
		103	These may serve another very important end. I will just mention it, though it is foreign to my present purpose. Several stars of the first magnitude have been observed or suspected to have a proper motion of their own; hence we may surmise that our sun, with

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			all its planets and comets, may also have a motion toward some particular point of the heavens. If this surmise should have any foundation it will show itself in a series of some years in a kind of systematical parallax or change due to the motion of the whole solar system.
1782	72	104	Theory of the annual parallax of double stars; General Postulata:
			1. Let the stars be supposed, one with another, to be about the size of the sun.
		104	2. Let the difference of their apparent magnitudes be owing to their different distances, so that a star of the 2d, 3d, 4th magnitude is 2, 3, 4 times as far off as one of the first.
		104	[Foot-note.] This is rather the order into which stars ought to be divided than that into which they are. And perhaps we ought to make an allowance for some loss which may happen to the light of very remote stars in its passage through immense tracts of space most probably not quite destitute of some very subtle medium.
			I have usually found very small telescopic stars to be red, or inclined to red.
		105	Case of the parallax of stars in the ecliptic.
		106	The following general expression for the parallax of two stars:
			Let P express the total parallax of a fixed star of the first magnitude; M the magnitude of the largest of the two stars; *m* the magnitude of the smallest, and *p* the partial parallax to be observed by the change in the distance of a double star; then will $p = \frac{m-M}{Mm}$. P and *p* being found by observation will give us $P = \frac{pMm}{m-M}$.
		107	Cases where the stars are not in the ecliptic.
1782	72	112	*Catalogue of Double Stars.* By Mr. HERSCHEL, F. R. S., communicated by *Dr.* WATSON, jun. Read January 10, 1782.
		112	Introductory remarks. The catalogue contains, I. The names of the stars, etc. II. Their comparative size. III. Their colors. IV. Their distances, which are given several different ways. Those estimated by the diameter can hardly be liable to an error of so much as 0″.25. Those measured by the micrometer may have errors from 1″ to 2″. A new micrometer [Lamp-Micrometer, P. T., 1782, p. 163], made within a few months, gives measures which can be relied on to 0″.1 when a mean of three measures is taken. V. The angles of position; when measured they can be relied on to 2° or 3°. VI. The dates of discovery.
		115	Catalogue of Double Stars; First Class [24 stars].
		120	*h* Draconis: "It is in vain to look for them if every circumstance is not favorable. The observer as well as the instrument must have been long enough out in the open air to acquire the same temperature. In very cold weather an hour at least will be required; but in a moderate temperature half an hour will be sufficient."
		122	Second Class of Double Stars [38 stars].
		128	*ζ Sagittæ:* the small star brighter with 460 than with 227 or 278.
		129	Third Class of Double Stars [46 stars].
		131	*γ Delphini:* "I suspect a motion in one of these stars. I thought it best not to join other observations" to those of 1779.
		136	Fourth Class of Double Stars [44 stars].
		142	Fifth Class of Double Stars [51 stars].

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1782 72 143 *ι Boötis:* "I suspect a motion in one of the stars, which another year or two may show."

143 *ν Draconis:* "From the position in FLAMSTEED's catalogue" we gather that in his time their distance was * * * *. The difference in the distance of the stars is so considerable that we can hardly account for it otherwise than by admitting a proper motion in one or both of the stars or in our solar system; most probably neither of the three is at rest."

147 *α Lyrae:* I have often measured the diameters of the fixed stars, and found they measured less and less the more I magnified. With a power of 6450 I looked at this star for at least a quarter of an hour, * * * having experimentally found that the aberration by this means will appear less and less. *α Lyræ* was perfectly round; its diameter was 0''.3553.

150 Sixth Class of Double Stars [66 stars].

150 *o Ceti:* "I can hardly doubt the motion of this star."

157 Postscript to the Catalogue of Double Stars.

Since delivering the paper on the Parallax of the Fixed Stars [*Phil. Trans.*, 1782], in which I refer to the above Catalogue of Double Stars, I have received a paper of Mr. MAYER's "De novis in Cœlo sidereo phænomenis" wherein I see that the idea of ascertaining the proper motion of the stars by means of small stars near large ones has induced that gentleman before me to look out for such small stars. My view being that the annual parallax required stars much nearer than
158 those that would do for Mr. MAYER's purpose, therefore I examined the heavens with much higher powers, and looked out chiefly for those that were exceedingly close. The above catalogue contains 269 double stars, 227 of which, to my present knowledge, have not been noticed by any person. I hope they will prove no inconsiderable addition to the general stock, especially as there are a great many which are out of the reach of Mr. MAYER's and other mural quadrants or transit instruments.

158 A power of 70 or 80 was not enough for the stars of Class I nor even those of Class II.

158 In settling the relative situation of very close double stars neither Mr. MAYER's instrument nor his method were adequate to the purpose.

159 Comparison of the measures of MAYER and HERSCHEL on *α Geminorum:*

"Mr. MAYER: Distance, 9''.635 from center to center; position, 23° 14' n. preceding; magnitude, extremely unequal. Mine: Distance, 5''.156, diameter included; position, 32° 47' n. preceding; magnitudes, a little unequal." [See Fig. 6, Plate IV, for a cut of the appearance of this star with power of 460.]

160 I do not mean to depreciate Mr. MAYER's method; with stars of Classes IV, V, VI, and some of Class III, better can hardly be wished for; it is not sufficient for stars of Class II, much less for those of Class I.

161 I have used the expression "double star" in a few instances of Class VI in rather an extended signification. I preferred that expression to any other such as comes, companion or satellite, because, in my opinion, it is much too soon to form any theories of small stars revolving round large ones.

162 I shall not fail to take the first opportunity for looking out for those of Mr. MAYER's double stars which I have not in my catalogue, amounting to 31, and also for [another in Connaissance des Tems].

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1782	72	163	*Description of a Lamp Micrometer, and the method of using it.* By Mr. WILLIAM HERSCHEL, F. R. S. Read January 31, 1782.
		163	The imperfections of the parallel wire micrometer in taking the measures of close double stars are [described]: 1st, that the measures must include the diamters of the stars; 2d, the deflection of the light on the wires [single threads of the silk-worm were used]; 3d, the uncertainty of the zero; 4th, the imperfection of the screw; 5th, the necessary illumination of the field.
		164	The *Lamp-Micrometer* is free from all these defects. Description and reference to Plate V.
		169	The powers of HERSCHEL'S telescopes were [at this time] determined by looking at a scale with one eye free and the other at the instrument.
		169	Description of the method of observing.
		170	"A little practice in this business soon makes it easy, especially to one who has already been used to look with both eyes open."
			Example of the measure of the position of *α Herculis.*
			("My telescope bears a power of 460 so well that for a twelvemonth past I have hardly used any other.")
		171	"A power of 932 on fine evenings is very distinct," and gives more than half an inch to a second on the Lamp-Micrometer.
		171	Other applications of this micrometer are to the measures of the diameters of the planets and satellites, the mountains of the moon, the diameters of the fixed stars, etc.
		171	Example of the measure of the diameter of *α Lyræ* [diameter $0''.355$].
		171	Nov. 28, 1781. I measured the diameter of the new star [*Uranus*]. The diameter of this "singular star" was $5''.022$.
1782	72	173	*A paper to obviate some doubts concerning the great magnifying powers used.* By Mr. HERSCHEL, F. R. S.
			[In the form of a letter to Sir JOSEPH BANKS, Prest. R. S.]
		173	I have the honor of laying before you the result of a set of measures I have taken to ascertain once more the powers of my Newtonian 7-feet reflector.
		174	The method described. The solar focus of one of the eye-pieces was measured five times and found to be 1.01, 1.04, 1.09, 1.01, 1.05 in half-inch measure. The sidereal focus of my 7-feet speculum in the same measure is 170.4. The mag. power of that lens is, then, 163.8. This eye-lens was then compared with others by measures of the diameter of a brass wire [details of the experiment given].
		175	Powers as they have been called in my papers, 146, 227, 278, 460, 754, 932, 1159, 1536 [this lens lost 8 months ago], 2010, 3168, 6450.
			Powers as they come out by this method, 163.86, 250.7, 301.8, 496.7, 775.1, 986.7, 1179.9, ——, 2175.8, 2585.5, 5786.8.
		175	Description of the method formerly used to determine these powers: In 1776 a mark of white paper exactly half an inch in diameter was viewed at the greatest convenient distance with the least magnifiers. An assistant was placed at rectangles in a field at the same distance, and upon a pole there erected I viewed the magnified image of the half inch which was marked by my direction. The power thus obtained was corrected to reduce it to what it would be upon infinitely
		176	distant objects. The powers of the rest of the lenses I deduced from this by a camera eye-piece. [See Plate VI, figs. 1 and 2.]

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1782 72 176 The inconvenience of the first method is that we find out how much the telescope *should* magnify rather than how much it really *does* magnify.

177 To prevent any mistakes I wish to mention again that I have all along proceeded experimentally in the use of my powers, and that I do not mean to say I have used 6450 (or 5786) upon the planets, or even upon double stars. The use of high powers is a new and untrodden path, and in this attempt variety of new phænomena may be expected, therefore I wish not to be in a haste to make general conclusions. I shall not fail to pursue this subject, and hope soon to be able to attack the celestial bodies with a still stronger armament which is now preparing.

1783 73 1 *A letter from William Herschel, esq., F. R. S.*, to Sir JOSEPH BANKS, Bart., P. R. S.

1 The name *Georgium Sidus* proposed for the new star discovered in March, 1781. [*Uranus.*]

1783 73 4 *On the Diameter and Magnitude of the Georgium Sidus; with a description of the dark and lucid disk and periphery micrometers.* By WILLIAM HERSCHEL, Esqr., F. R. S. Read November 7, 1782.

5 The measures of the diameter of the *Georgium Sidus* formerly communicated give 4″ 36¼‴. But not being satisfied, when I thought it possible to obtain much more accurate measures, I employed the lamp micrometer.

5 A lucid disk and not two lucid points was really required, and the following apparatus was contrived. [Description follows.] The
6 planet was kept by a good screw opposite and covering illuminated oiled paper disks, and the sizes of these measured.

7 Observations on the Light, Diameter, and Magnitude of the *Georgium Sidus.* [From Oct. 22, 1781, to Nov. 4, 1782.]

7 Oct. 22, 1781, "had a fine, bright, steady light, of the color of *Jupiter*, or approaching to the light of the moon."

8 Oct. 2, 1782. "The planet unexpectedly appeared bluish," while the oiled disk was reddish.

9 Oct. 10, 1782, determined the magnifying power of the telescope again in a new way [described].

11 There is one cause of inaccuracy or deception in very small [close] measures, long suspected but never yet sufficiently investigated. A *dispersion* of the rays of light in the atmosphere may be admitted; a *concentration* may also take place.

11 Oct. 12, 1782. The planet visible to the naked eye.

11 Oct. 13, 1782. "I perceived no flattening of the polar regions."

12 Nov. 4, 1782. "I was now fully convinced that light, be it in the form of a lucid circle or illuminated periphery, would always occasion the measures to be less than they should be, on account of its vivid impression upon the eye" [and a dark circle in a bright square was used for comparison].

12 A method to discover the quantity of the deception arising from the illumination pointed out.

13 The diameter of the *Georgium Sidus* cannot well be much less, nor perhaps much larger, than about 4″.

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1783 73 247 *On the proper motion of the Sun and Solar System; with an account of several changes that have happened among the fixed stars since the time of* Mr. Flamsteed. By William Herschel, Esq., F. R. S.

Read March 6, 1783.

247 Several of the fixed stars have a proper motion.

248 We may strongly suspect that there is not, in strictness of speaking, one *fixed* star in the heavens, and reasons which I shall adduce will render this so obvious that there can hardly remain a doubt of the general motion of all the starry systems, and, consequently, of the solar one among the rest.

248 Reasons drawn from the theory of attraction evidently oppose every idea of absolute rest in any one of the stars, when once it is known that some of them are in motion.

249 I will give a general account of the most striking changes which I have found to have happened in the heavens since Flamsteed's time. I have now almost finished my third review.

249 The first review was made with a Newtonian telescope something less than 7 feet focal length, a power of 222, and an aperture of 4½ inches. It extended only to stars of the first, second, third, and fourth magnitudes.

249 Of my second review I have given some account in *Phil. Trans.*, vols. LXX, LXXI, LXXII. It was made with an instrument much superior to the other of 85.2 inches focus, 6.2 inches aperture, and power 227. It extended to all the stars of Harris's maps, and the telescopic ones near them as far as the eighth magnitude. The Catalogue of Double Stars and the discovery of the *Georgium Sidus* were the results of that review.

My third review was with the same instrument and aperture, but
250 with a power of 460. This extended to all the stars of Flamsteed's catalogue, together with every small star about them, to the amount of a great many thousands of stars.

250 It may be proper to mention that I have many a night, in the course of 11 or 12 hours of observation, carefully and singly examined not less than 400 celestial objects, besides taking measures, and sometimes viewing a particular star for half an hour together, with all the various powers.

250 The particularities attended to in this [third] review were—

1. The existence of the star itself, such as it is given by Flamsteed.
2. To observe well whether it was single or double, well defined or hazy.
3. To view and mark down its particular color.
4. To examine all the small stars in the neighborhood as far, at least, as the twelfth magnitude.

The results of these observations I shall collect under a few general heads, as follows:

250 I. Stars that are lost or have undergone some capital change since Flamsteed's time.

254 II. Stars that have changed their magnitude since Flamsteed's time.

257 III. Stars newly come to be visible.

[Several red and garnet stars in this list.]

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1783 73 258 Here we ought to observe that it is not easy to prove a star to be newly come.

259 "Does it not seem natural that these observations should cause a strong suspicion that most probably every star in the heavens is more or less in motion?" For though their proper motions could not cause all these changes, yet we may well suppose that motion is in some way concerned.

259 A slow motion, for instance, in an orbit round some opaque body might account for some of these changes, while others might be owing to the periodical return of large spots, which become visible by a rotation. The idea also of a body flattened by a quick rotation and having a motion whereby more of the luminous surface would be exposed at one time than another tends to the same end.

260 If the proper motion of the stars be admitted, who can deny that of our sun? Admitting this for granted, the greatest difficulty will be to discern the proper motion of the sun between so many other motions of the stars. This is an arduous task indeed, but we are not to be discouraged in the attempt. Let us at all events endeavor to lay a good foundation for those who are to come after us. I shall therefore now point out the method of detecting the direction and quantity of the supposed proper motion of the sun, and show that we have already some reasons to guess which way the solar system is probably tending its course. [See Figs. 1 and 2.]

261 From the explanation of the figures it follows that—

1. The greatest or total systematical parallax of the fixed stars will fall upon those that are in the line DE at rectangles to the direction AB of the sun's motion.
2. The partial systematical parallax of every other star [defined in amount].
3. The parallax of stars at different distances will be inversely as those distances.
4. Every star at rest, to a system in motion. will appear to move in a direction contrary to that in which the system is moving.

Hence it follows that if the sun be carried toward any star in the ecliptic, every star in [one half of the ecliptic] will decrease in longitude, and every star in [the other half] will increase.

262 No method is so proper for this purpose as to divide our observations into 3 zones, viz: the equator and the two colures, and double stars are the most suitable for the purpose. Each of the 3 zones [contains double stars, which are in the previous list].

263 The equatorial zone, 20° wide, contains 150 stars. [List of them given.]

264 The zone of the equinoctial where 20° wide contains 70 double stars. [List given.]

265 The zone of the solstitial where 20° wide contains 120 double stars. [List given.]

266 A zone 20° wide of the ecliptic of 120 double stars may be added. [List given.]

266 It remains now only for me to make an application of this theory to some of the facts we already know.

267 And first let me observe that the rules of philosophizing direct us to refer all phenomena to as few and simple principles as are sufficient to explain them. [An example given.]

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1783 73 267 Dr Maskelyne's proper motions of seven of the stars quoted, and the positions of these stars plotted on Fig. 3.

268 The motion of the sun towards the constellation of *Hercules* from a point not far from the 77th degree of right ascension to its opposite 257th degree will account for the proper motions of these stars by the single motion of the Solar System.

269 Lalande gives the proper motion of 12 stars [table], and Fig. 4 rep-
270 resents them projected on the plane of the equator. These stars with others [named] give us 27 motions to be accounted for. Our supposition of the sun's motion accounts for 22 of these, so there
271 are but 5 exceptions, which must be resolved into the real proper motions of the stars.

272 The apparent exception of *Castor* considered [and the physical connection of the two components is not assumed].

273 The apex of the solar motion defined.

273 As to the quantity of the solar motion I can only offer a few distant hints.

274 The solar motion can certainly not be less than that which the earth has in her annual orbit.

274 Future observations will soon throw more light on this interesting subject, and either fully establish or overthrow the hypothesis. To this end I have already begun a series of observation upon several zones of double stars, and should the result of them be against these conjectures I shall be the first to point out their fallacy. [Dated at Datchet, near Windsor, Feb. 1, 1783.]

274 *Postscript to the paper on the Motion of the Solar System.*
Mr. Aubert has furnished me with Tob. Mayer's *Opera Inedita*, which contains a catalogue of 80 stars observed by Mayer in 1756, compared with Roemer's observations of 1706.

275 I have used these stars and left out of the list all those whose proper motions Mayer considers doubtful and the fourteen stars already examined, and which have been shown to support the hypothesis. The rest are drawn up in two tables. The first contains the stars that agree with my assigned motion of the solar system. The second contains those stars whose motions cannot be accounted for on my hypothesis, and must therefore be ascribed to a real motion in the stars themselves or to some *still more hidden* cause of a *still remoter* parallax.

[This phrase is explained by a foot-note, as follows:]

276 [Foot-note.] Mr. Michell's admirable idea of the stars being collected into systems appears to be extremely well founded; though it does not, in my opinion, take away the probability of many stars being still, as it were, *solitary* or *intersystematical*. Hence there may be a proper motion of the whole system to which a star belongs. Examples given of an inhabitant of *Saturn's* fifth satellite; or a small nebula may consist of many stars and have a proper motion as a system.

277 [Foot-note.] We see, then, that while the sun is going toward a certain point of the heavens each of the stars belonging to the sidereal system, of which the sun is one, will be affected as I have shown [p. 261] notwithstanding the whole system should have a real motion in absolute space, and change its position with respect to other systems or intersystematical stars.

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1783	73	277	[Foot-note.] And should there ever be found, in any particular part of the heavens, a concurrence of proper motions of quite a different direction we shall then perhaps begin to form some conjectures as to which stars may possibly belong to ours and which to other systems.
		278	Discussion of the data of the tables.
		279	The general law according to which the declinations of the stars are governed is this: Let an arc of 90° be applied to the sphere of the fixed stars so as always to pass through the apex of solar motion. Then while one end of it is drawn along the equator the other will describe a closed curve. The law is that all stars in the northern hemisphere situated within the nodated part will seem to go to the north by the motion of the solar system; the rest will appear to go southward. A similar law applies for the southern hemisphere. See Fig. 5 and Fig. 6 and the explanation, p. 280.
		281	A paragraph of MAYER'S [quoted] which seems to contain an objection against the solar motion is really a good argument in its favor, as is shown. MAYER'S paper was read in 1760, and mentions the motion of the solar system as a very possible thing, and points out some of the consequences of such a motion.
		283	The foot-note gives a reference to two other papers of the same sort, one by WILSON (1777), and one by LALANDE (1776).
1784	74	233	*On the remarkable appearances at the polar regions of the planet Mars, the inclination of its axis, the position of its poles, and its spheroidical figure; with a few hints relating to its real diameter and atmosphere.* By WILLIAM HERSCHEL, Esq., F. R. S. Read March 11, 1784.
		234	The polar spots of *Mars* may afford a good means of "settling the inclination and nodes of that planet's axis." It was a question to be settled by observation how far these spots were permanent and in what latitude of Mars they were situated.
		235	*Observations* from 1777, April 17, to 1783, Nov. 11. See Plate VI, where there are 24 drawings.
		237	1783, May 20. The polar spot, which is bright, seems to project above the disk by its splendor.
		238	[From observations up to 1783, Sept. 25.] I concluded that none of the bright spots were exactly at the poles, though not far from them.
		241	Appearances explained by graphical constructions, Plates VII, VIII, IX, X.
		243	Table giving the synodical places of the spots at the times of the different observations.
		247	*Of the direction or nodes of the axis of Mars, its inclination to the ecliptic, and the angle of that planet's equator with its own orbit.*
		248	Observations of angle of position of the polar spots.
		252	Method of correcting the observations.
		254	Table of resulting corrections.
		254	From 13 observations reduced to 1783, October 4, the position of the axis of *Mars* was 55° 41′ *s.f.*
		256	From 2 observations reduced to 1781, June 25, this position was 75° 11′ *s. p.*
		256	The north pole of *Mars* must be directed towards some point of the heavens between 9 *s.* 24° 35′ and 0 *s.* 7° 15′.
		258	Method of reducing the elements from the ecliptic to the orbit of *Mars.*

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1784 74 259 *Inclination* of the axis of *Mars* 61° 18′ to the orbit; the *node* being in 19° 28′ of *Pisces*.

260 The analogy between *Mars* and the earth pointed out.

260 The bright polar spots are probably owing to the vivid reflection of light from frozen regions, and the reduction [in size] of these spots is to be ascribed to their being exposed to the sun.

261 *Of the spheroidical figure of Mars.*

262 *Observations relating to the polar flattening of Mars.*

These all show a difference in the polar and equatorial diameters; even when the mirrors of the telescopes are turned 90° in their tubes, and various telescopes employed.

266 To avoid the corrections for phase, the measures taken on the day of opposition will be adopted, these having been satisfactory.

267 The equatorial diameter of *Mars* is to the polar as 1355 to 1289.

268 Corrections to this ratio considered, and the former result changed to 1355 to 1272, or as 16 to 15 nearly.

270 This difference does not depend on distortions from the eye-pieces or objectives employed.

271 The equatorial diameter of *Mars* at distance 1 is 9″ 8‴.

271 The atmosphere of *Mars*. Dr. SMITH reports an observation of CASSINI'S where a star about to be occulted by *Mars* became extremely faint 6′ from the disk of the planet.

272 Observations by HERSCHEL of faint stars near *Mars*, which show them not to be more affected than the nearness of its superior light would warrant.

273 From other phenomena it appears, however, that this planet is not without a considerable atmosphere; for besides the permanent spots on its surface I have often noticed changes in both bright and dark belts, and these alterations we can hardly ascribe to any other cause than the variable disposition of clouds and vapors floating in the atmosphere of that planet.

273 *Result of the contents of this paper:*

The axis of *Mars* is inclined to the ecliptic 59° 42′.

The node of the axis is in 17° 47′ of *Pisces*.

The point *Aries* on the Martial ecliptic answers to our 19° 28′ of *Sagittarius*.

The figure of *Mars* is that of an oblate spheroid whose equatorial diameter is to the polar one as 1355 to 1272, or as 16 to 15 nearly.

The equatorial diameter of *Mars* reduced to the mean distance of the earth from the sun is 9″ 8‴.

And that planet has a considerable but moderate atmosphere, so that its inhabitants probably enjoy a situation in many respects similar to ours.

[Dated] Datchet, Dec. 1, 1783.

1784 74 437 *Account of some observations tending to investigate the construction of the heavens.* By WILLIAM HERSCHEL, Esq., F. R. S. Read June 17, 1784.

437 A new Newtonian telescope has lately been completed, the object speculum being 20 feet in focal length and its aperture $18\frac{7}{10}$ inches.

It is mounted in the meridian and gives positions only in a coarse way.

437 It would perhaps have been more eligible to have waited longer in order to complete the discoveries that seem to lie within the reach

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of this instrument, and are already, in some respects, pointed out to me by it.

1784 74 437 By taking more time I should undoubtedly be enabled to speak more confidently of the *interior construction* of the heavens and its various *nebulous and sidereal strata*, of which this paper can give only a few hints.

438 As an apology for this prematurity it may be said that the end of all discoveries being communication, we can never be too ready in giving facts and observations, whatever we may be, in reasoning upon them.

438 Hitherto the sidereal heavens have been represented by the concave surface of a sphere. In future we shall look upon those regions into which we may now penetrate as a naturalist regards a rich extent of ground containing strata variously inclined and directed as well as consisting of very different materials.

438 Resolution of the milky way.

439 Number of stars visible in field of the 20-foot telescope.

440 Examination of MESSIER'S nebulæ.

442–446 New nebulæ have been found with the first 20-foot reflector of 12 inches aperture; figures of some of these given in Plate XVII.

442 Arrangement of nebulæ and clusters in *strata*, sometimes of great length.

443 Sun near the centre of the milky way. See Plate XVIII.

445 Star gauging defined.

446 Table of results of star gauging from $15^h 01^m$ to $16^h 37^m$ R. A. and from 92° to 94° N. P. D., and $11^h 16^m$ to $14^h 30^m$ and 78° to 80° N. P. D.

448 The solar motion explained by the situation of the sun in the milky way.

448 Local distribution of nebulæ—nebulæ are often surrounded by spaces vacant of stars.

449 Strata of *Cancer* and *Coma Berenices* described.

449 Although my single endeavors should not succeed in a work which seems to require the joint effort of every astronomer, yet so much we may venture to hope that by applying ourselves with all our powers to the improvement of telescopes, which I look upon as yet in their infant state, and turning them with assiduity to the study of the heavens, we shall in time obtain some faint knowledge of, and perhaps be able partly to delineate, the interior construction of the universe.

With this memoir is a plate of figures of nebulæ. Plate XVII, fig. 1, M. 98; 2, M. 53; 3, H., ii, 28 [resolvable]; 4, H., i, 18; 5, H, iii, 15; 6, H., iv, 5; 7, H, iv, 2; 8, H, iv, 3; 9, 10; 11, H, i, 13; 12, 13, 14, 15?

Also Plate XVIII, construction of the heavens—cloven disk.

1785 75 40 *Catalogue of Double Stars.* By WILLIAM HERSCHEL, Esq., F. R. S. Read December 9, 1784.

40 Introductory remarks. The great use of double stars having already been pointed out in a former paper on the Parallax of the Fixed Stars, and in a latter one on the Motion of the Solar System, I have now drawn up a second collection of 434 more, which I have found out since the first was delivered.

The method of classing them is in every respect the same as that which is used in the first collection.

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1785 75 41 Method of identifying and describing the positions of the stars.

43 I would recommend a precaution to those who wish to examine the closest of my double stars. It relates to the adjustment of the focus. Supposing the telescope and the observer long enough out in the open air to have acquired a certain temperature, and the night sufficiently clear, let the focus be readjusted with the utmost delicacy upon a star known to be single, of nearly the same altitude, magnitude, and color as the star to be examined.

44 Let the phenomena of the adjusting star be well attended to, as to whether it be perfectly rounded and well defined, or affected with little appendages, etc. Such deceptions may be detected by turning or unscrewing the object glass a little in its cell, when those appendages will be observed to revolve the same way.

44 Being thus acquainted with the imperfections as well as the perfections of the instrument, and going immediately from the adjusting star, we may hope to be successful.

45 All the observations here given were made with a power of 460 unless they are marked otherwise.

45 The measures were all taken with a parallel silk-worm's-thread micrometer and a power of 227 only, from the center of one star to the center of the other.

46 The threads subtend an angle of 1″ 13‴ only.

46 The positions have all been measured with a power of 460 on a micrometer made for me according to the model given in the *Phil. Trans.*, vol. lxxi, page 500, fig. 4.

W. Herschel.

[Dated] Datchet, near Windsor, Nov. 1, 1784.

47 Catalogue of Double Stars, First Class. [Nos. 25 to 97.]

48 [Foot-note.] Could we increase our power and distinctness at pleasure we might undoubtedly separate any two stars that are not absolutely in a direct line. * * * This will appear when we consider that perhaps $\frac{58}{60}$ of the diameter of a star are spurious. It would have been curious if a considerable difference in the colors could have led us to discover which of the two stars is before the other! But by far the greatest part of their diameters being spurious, it is probable that a different-colored light of two stars would join together where the rays of one extend into those of the other; and so, producing a third color by the mixture, still leave the question undecided.

51 [Foot-note.] The interval between very unequal stars estimated in diameters generally gains more by an increase of magnifying power than the apparent distance of those which are nearer of a size. However, this only seems to take place when there is a difficulty of seeing the object well with a low power.

65 Second Class of Double Stars. [Nos. 39 to 102.]

[Foot-note.] When the small star is so faint as not to bear the least illumination of the wires, its position may still be measured by the assistance of some wall or other object; for an eye which has been some time in the dark can see a wall in a starlight night sufficiently well to note the projection of the stars upon it in the manner which has been described with the lamp micrometer. Then introducing some light, and adapting the fixed wire to the observed direction

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of the stars on the wall, the moveable wire may be set to the parallel of the large star, which will give the angle of position pretty accurately.

1785 75 78 Third Class of Double Stars. [Nos. 47 to 114.]

82 [Foot-note.] With regard to small stars that become visible by an increase of magnifying power, we may surmise that it is partly owing to the greater darkness of the field of view arising from the increased power, and partly to the real effect of the power.

83 [Foot-note.] The prismatic power of the atmosphere, of which little notice has been taken by astronomers, is that part of its refractive quality whereby it disperses the rays of light and gives a lengthened and colored image of a lucid point. It is very visible in low stars; *Fomalhaut*, for instance, affords a beautiful prismatic spectrum [experiments given], which explain also why a star is not always best in the center of the field of view; a fact I have often noticed before I knew the cause.

91 Fourth Class of Double Stars. [Nos. 45 to 132.]

105 Fifth Class of Double Stars. [Nos. 52 to 137.]

118 Sixth Class of Double Stars. [Nos. 67 to 126.]

126 Additional Errata to the Catalogue of Double Stars, Phil. Trans., vol. lxxii.

126 Plate V gives figures of 44 *Lyncis* and *μ Aurigæ*.

1785 75 213 *On the Construction of the Heavens.* By William Herschel, Esq., F. R. S. Read Feb. 3, 1785.

213 In an investigation of this delicate nature we ought to avoid two opposite extremes. If we indulge a fanciful imagination and build worlds of our own, we must not wonder at our going wide from the path of truth and nature. On the other hand, if we add observation to observation, without attempting to draw not only certain conclusions but also conjectural views from them, we offend against the very end for which only observations ought to be made. I will endeavor to keep a proper medium, but if I should deviate from that, I could wish not to fall into the latter error.

214 Theoretical view of the formation of nebulæ.

Form I. Condensation of neighboring stars about a central and larger star; globular forms.

215 *Form II.* Condensation of neighboring stars about a nucleus of contiguous stars; condensed irregular forms.

Form III. Condensation about a stream of stars, producing a form coarsely similar to the prototype: extended, branching, compound forms.

216 *Form IV.* Compound forms derived from the mutual attraction of clusters.

V. Vacancies will then arise in the surrounding space.

Objection to the above views; they tend to show a gradual destruction of the universe. Response, that space is infinite and that the occasional destruction of one star may operate to give life to the rest.

217 Optical appearances to an observer within a nebula of the third form.

219 Results of observation—star gauges.

221–240 Gauges throughout the 24^h in R. A. Results given in detail in a Table.

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A. D.	*Vol.*	*P.*	
1785	75	241	The stars being supposed to be nearly equally scattered, and their number in a field of view of known angular diameter being given, to determine the length of the visual ray. Solution of the problem.
		243	Another solution.
		244	*We inhabit the planet of a star belonging to a Compound Nebula of the third form.*
		244	Proof that the sun is situated in a compound nebula of Form III.
		250	*Use of the gauges.*
		253	*Section of our sidereal system.*
		254	*The origin of nebulous strata.*
		256	*An Opening in the Heavens.* M. 80 and M. 4 on the edges of vacancies.
		257	*Phenomena at the Poles of our nebula.*
		258	*Enumeration of very compound nebulæ or milky ways.* Ten described, including those of *Orion* and *Andromeda.*
		263	*A Perforated Nebula or Ring of Stars.* Account of nebula of *Lyra.* G. C., 4447.
			Planetary nebulæ. Observations of G. C., 4628, 4964, 4572, 4565, 826, 2102, 4302.
		266	The accompanying plate, viii, gives a figure of a section of the milky way.
1786	76	457	*Catalogue of one thousand New Nebulæ and Clusters of Stars.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read April 27, 1786.
		457	Description of sweeping telescope; Newtonian; 20 feet focus, 18.7 in. aperture, power 157, field 15′ 14″.
		458	Description of the method of sweeping.
		464	Probable errors of the places given by the sweeps before 1783, Dec. 13, $\Delta\alpha = 1^m$; $\Delta\delta$ 8′–10′, during 1784 $\Delta\alpha < 30^s$; $\Delta\delta < 5'$. Till 1785, September 24, $\Delta\alpha < 12^s$; $\Delta\delta < 4'$. Till 1786, April, $\Delta\alpha < 6^s$; $\Delta\delta < 2'$.
		466	When the diurnal motion of the earth was first maintained it could not but add greatly to the reception of this opinion when the telescope showed *Jupiter, Mars,* and *Venus* revolving on their axes; in the same way the view of so many sidereal systems will add credit to what I have said in regard to the construction of the heavens. For to the inhabitants of the nebulæ of the present catalogue our sidereal system must appear either as a small nebulous patch; an extended streak of milky light; a large resolvable nebula; a very compressed cluster of minute stars, hardly discernible; or as an immense collection of large scattered stars of various sizes, according as their situation is more or less remote from ours.
		466	Definition of *classes* of nebulæ and clusters.
		467	A map of positions of nebulæ was made for identification [by means of which the laws of aggregation of the nebulæ were gradually discovered].
		469	Explanation of a short method of describing the appearance of a nebula by letters.
		471	Catalogue:
		471	Class I No. 1 to No. 93
		473	II No. 1 to No. 402
		482	III No. 1 to No. 376
		492	IV No. 1 to No. 29
		493	V No. 1 to No. 24

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494 Class VI No. 1 to No. 19

496 VII No. 1 to No. 17

496 VIII No. 1 to No. 40

498 Notes to special nebulæ.

1786 76 500 *Investigation of the cause of that indistinctness of vision which has been ascribed to the smallness of the optic pencil.* By WILLIAM HERSCHEL, LL.D., F. R. S. Read June 22, 1786.

500 Soon after my first essay of using high powers with the Newtonian telescope, I began to doubt whether an opinion which has been entertained by several eminent authors "that vision will grow indistinct when the optic pencils are less than the fortieth or fiftieth part of an inch" would hold good in all cases.

I perceived that, according to this criterion, I was not entitled to see distinctly with a power much more than about 320 in a 7-foot telescope of an aperture of 6.4 inches; whereas in many experiments I found myself very well pleased with magnifiers which far exceeded such narrow limits.

This induced me, as it were, by way of apology to myself for seeing well where I ought to have seen less distinctly, to make a few experiments.

501 The first experiments I made were in 1778, and the result of them proved so decisive that I have never since resumed the subject, and had it not been for a late conversation with some of my highly esteemed and learned friends, I might probably have left the papers on which these experiments were recorded among the rest of those that are laid aside when they have afforded me the information I want.

501 *Experiments with the naked eye.*

502 *Microscopic experiments.*

Exp. 3. With a pencil of $\frac{1}{232}$ of an inch I saw very distinctly.

503 Exp. 4. With a pencil of $\frac{1}{724}$ of an inch I saw very distinctly.

Exp. 5. With a pencil of $\frac{1}{1800}$ of an inch I saw very distinctly.

Exp. 8. With a pencil of $\frac{1}{2173}$ of an inch I saw very distinctly.

504 Exp. 10. It occurred to me that a certain proportion of aperture might be necessary to a given focal length of an object-glass or speculum.

505 Exp. 10, 11, 12, 13, show that to see well in microscopes like the one used, the aperture of the object glass must bear a considerable proportion to its focal length.

505 Exp. 15 shows that $\frac{1}{34}$th part of the focal length is not a sufficient aperture.

507 As soon as convenient I intend to pursue this subject; at present my engagement with the work of a 40-feet reflector will hardly permit so much leisure, and till I have repeated, extended, and varied these experiments, I would wish them to be looked upon as mere hints.

1787 77 4 *Remarks on the new Comet.* In a letter from WILLIAM HERSCHEL, LL. D., F. R. S., to CHARLES BLAGDEN, M. D., Sec. R. S. Read Nov. 16, 1786. [Dated Slough, near Windsor, Nov. 15, 1786.] [This comet was discovered by CAROLINA HERSCHEL, August 1, 1786, during the absence of WILLIAM HERSCHEL on a visit to Germany. It was comet 1786, II.]

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1787 77 125 *An account of the discovery of two satellites revolving round the Georgian Planet.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read Feb. 15, 1787.

125 I had frequently directed large telescopes to this remote planet to see if it were attended by satellites, but failed for the want of sufficient light in the instruments I used.

126 In the beginning of [January, 1787] I found that my telescope used as a *front view* gave much more light. On the 11th of January I selected a sweep which included the *Georgian Planet*, and noted down the places of the small stars near it. The next day two of these were missing. To satisfy myself I noted down all the small stars on the 14th, 17th, 18th, and 24th of January, and the 4th and 5th of February, and though I had no longer any doubt of the existence of at least one satellite, I thought it right to defer this communication till I could see it actually in motion. Accordingly I began to pursue this satellite on February the 7th, at about 6 o'clock in the evening, and kept it in view till three in the morning on Feb. the 8th, and during those nine hours I saw this satellite faithfully attend its primary planet and describe a considerable arc of its proper orbit.

126 While I was attending to the motion of this satellite I did not forget to follow another small star which I was pretty well assured was also a satellite.

127 The first-discovered satellite [*Oberon*] is the farthest from the planet and I shall call it the *second satellite;* the last-discovered [*Titania*] I shall call the *first satellite.*

127 I made a sketch on paper to point out beforehand the situation of these satellites on Feb. 10, and [on that night] the heavens displayed the original of my drawing by shewing, in the situation I had delineated them, *the Georgian Planet attended by two satellites.* I confess that this scene appeared to me with additional beauty as the little secondary planets seemed to give a dignity to the primary one which raises it into a more conspicuous situation among the great bodies of our solar system.

128 I suppose the *first* performs a synodical revolution in about 8¾ days, the *second* in nearly 13½ days. Their orbits make a considerable angle with the ecliptic.

129 Attempts to measure them with my micrometers have so far failed. I have nevertheless several resources in view and do not despair of succeeding pretty well in the end.

W. HERSCHEL.

[Dated] Slough, near Windsor, February 11, 1787.

1787 77 229 *An account of Three Volcanoes in the Moon.* By WILLIAM HERSCHEL, LL. D., F. R. S.; communicated by Sir JOSEPH BANKS, Bart., P. R. S. Read April 26, 1787.

229 The phenomena of nature are to be viewed not only with the usual attention to facts as they occur, but with the eye of reason and experience. In this we are not allowed to depart from plain appearances. Thus when we see on the surface of the moon a great number of elevations from half a mile to a mile and a half in height we are strictly entitled to call them mountains; but when we attend to their particular shape, in which many of them resemble the craters of our volcanoes, and thence argue that they owe their origin to the same cause which has modeled many of these, we may be said to see by analogy, or with the eye of reason.

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1787 77 229 In this latter case, though it may be convenient to use expressions which can only be justified by reasoning upon the facts themselves, it will certainly be the safest way not to neglect a full description of them, that it may appear to others how far we have been authorized to use the mental eye.

1787 77 230 April 19, 1787, $10^h\,36^m$ sidereal time, three volcanoes seen; April 20, 1787, $10^h\,2^m$ sidereal time, one of the three burns with greater violence than last night. The diameter of the volcano is twice that of *Jupiter's* satellite III.

231 The appearance of the actual fire exactly resembled a small piece of burning charcoal when it is covered with a very thin coat of white ashes. All the adjacent parts of the volcanic mountain seemed to be faintly illuminated by the eruption and were gradually more obscure as they lay at a greater distance from the crater. This eruption resembled much that which I saw on the 4th of May, 1783,* an account of which I shall shortly lay before the society.

WILLIAM HERSCHEL.

[Dated] Slough, near Windsor, April 21, 1787.

232 Note on M. MÉCHAIN'S comet. [1787, I.]

1787 77 364 *On the Georgian Planet and its satellites.* By WILLIAM HERSCHEL, LL. D. F. R. S. Read May 22, 1788.

In a former paper I gave the periodical times of two satellites revolving round the *Georgian Planet* in a general way. While it requires a much longer series of observations than I have had an opportunity of making to settle their mean motions with accuracy, I shall communicate the result of my past observations, and believe that the elements here delivered will be found to be full as accurate as we can at this time expect.

365 Methods of measuring angles of position which were employed.

365 Synodical revolution of Satellite I $= 8^d\,17^h\,1^m\,19.3^s$. [*Titania.*]

365 Synodical revolution of Satellite II $= 13^d\,11^h\,5^m\,1.5^s$. [*Oberon.*]

366 Other elements.

368 Mass of [*Uranus*] is 17.740612 times the earth's mass.

369 Diameter of [*Uranus*] is assumed 4''.04625.

370 Difficulties in making the measures of satellites stated.

371 Measures of Satellite I and discussion of these.

376 The light of these satellites is uncommonly faint. The second [*Oberon*] is the brighter of the two, but the difference is not considerable.

377 Elements of the orbits. W. HERSCHEL.

378 Plate V of diagrams. [Dated] Slough, March 1, 1788.

1789 79 151 *Observations on a Comet.* In a letter from WILLIAM HERSCHEL, LL. D., F. R. S., to Sir JOSEPH BANKS, Bart., P. R. S. Read April 2, 1789. Letter dated Slough, March 3, 1789. [This was comet 1788, II.]

151 The comet was discovered by CAROLINA HERSCHEL, December 21, 1788, and positions of it on December 22, 1788, are given.

153 No solid nucleus, even so small as 1'', could be seen, and the same fact has been observed by me in three other comets.

1789 79 212 *Catalogue of a second thousand of New Nebulæ and Clusters of Stars; with a few introductory Remarks on the Construction of the Heavens.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read June 11, 1789.

213 A telescope has power to penetrate into space. Proof that every star is a sun shining by its native brightness.

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* This observation is reported by Baron von TACH in BODÉ'S *Jahrbuch*, 1788, p. 144.

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1789 79 214 Systems of stars—globular clusters and definition of a cluster.

216 Admitting that a cluster is real, not apparent, the stars composing it are about of equal magnitude.

217 At the same distance from the centre an equal scattering takes place.

217 These clusters are of a globular form.

218 They are more condensed at the centre than at the surface.

219 Form I of nebulæ [*Phil. Trans.*, 1785, p. 214], is thus shown to exist in the heavens.

219 Such clusters are subject to central powers.

220 The idea of other central forces [than that of gravity] in the construction of the sidereal heavens, was given in certain mathematical papers delivered to the Philosophical Society of Bath [and is yet entertained].

221 Not only were *round* nebula and clusters formed by central powers, but likewise every cluster of stars or nebula that shows a gradual condensation, or increasing brightness towards a centre.

222 This theory of central power is fully established on grounds [of observation] which cannot be overturned.

223 Clusters can be found of 10′ diameter with a certain degree of compression and stars of a certain magnitude, and smaller clusters of 4′ 3′ 2′ in diameter, with smaller stars and greater compression, and so on through resolvable nebulæ by imperceptible steps, to the smallest and faintest [and most distant] nebulæ.

224 Other clusters there are, which lead to the belief that either they are more compressed or are composed of larger stars. Spherical clusters are probably not more different in size among themselves than different individuals of plants of the same species. As it has been shown that the spherical figure of a cluster of stars is owing to central powers, it follows that those clusters which, *cæteris paribus*, are the most complete in this figure, must have been the longest exposed to the action of these causes.

225 The maturity of a sidereal system may thus be judged from the disposition of the component parts. Planetary nebulæ may be looked on as very aged.

226 This method of viewing the heavens seems to throw them into a new kind of light. They are now seen to resemble a luxuriant garden which contains the greatest variety of productions in different flourishing beds; and one advantage we may at least reap from it is that we can, as it were, extend the range of our experience to an immense duration. For, is it not almost the same thing whether we live successively to witness the germination, blooming, foliage, fecundity, fading, withering, and corruption of a plant, or whether a vast number of specimens, selected from every stage through which the plant passes in the course of its existence, be brought at once to our view?

WILLIAM HERSCHEL.

[Dated] Slough, near Windsor, May 1, 1789.

226 Catalogue:

P.	Class				
226	Class I	No. 94	to	No. 215
229	II	No. 403	to	No. 768
238	III	No. 377	to	No. 747
246	IV	No. 30	to	No. 58
248	V	No. 25	to	No. 44
250	VI	No. 20	to	No. 35

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1789 79 251 Class VII No. 18 to No. 55

253 VIII No. 41 to No. 78

255 Notes.

255 P. S.—The planet *Saturn* has a *sixth satellite* revolving round it in about 32 hours 48 minutes. Its orbit lies exactly in the plane of the ring. An account of its discovery with the 40-foot reflector, etc., will be presented to the Royal Society at their next meeting.
William Herschel.

1790 80 1 *Account of the discovery of a sixth and seventh satellite of the planet Saturn; with remarks on the construction of its ring, its atmosphere, its rotation on an axis, and its spheroidical figure.* By William Herschel, LL. D., F. R. S. Read November 12, 1789.

1 In a postscript to my last paper I announced to the Royal Society the discovery of a satellite of *Saturn*. I have now the honor to present them, with an account of two satellites instead of one, and I have called them the *sixth* and *seventh*, although their situation very probably entitles them to be called the first and second.

2 These have not been before discovered on account of the difficulty of seeing them with a less telescope than the 40-foot.

2 I began to observe *Saturn* in 1774, and on March 17 I saw it with a 5½-foot reflector, as in Plate I, fig. 1. Fig. 2 shows it on April 3, 1774, without its ring. In 1775 I saw the ring gradually open (using a 7-foot reflector). Fig. 3, Plate II, shows the appearance 1784 [should be 1778], June 20 (with a very good 10-foot reflector).

3 The black belt on the ring of *Saturn* is not in the middle of its breadth, nor is the ring subdivided by many such lines, but there is one single, considerably broad belt upon the ring which is permanently in its place.

3 My observations show that this belt (at least on the north half of the ring, where I have alone observed it) is not like the belts of *Jupiter* or those of *Saturn*, subject to variations of color or figure, but is most probably owing to some permanent construction of the surface of the ring itself.

3 It is not the shadow of a chain of mountains, since it is visible all round the ring. The same argument will hold good against supposed caverns or concavities. It is pretty evident that it is contained between two concentric circles. See fig. 4, Plate II, drawing of 1780, May 11.

4 As to the surmise of two rings, it does not appear eligible to venture on so artificial a construction, by way of explaining a phenomenon, which does not absolutely demand it.

4 As yet we do not know of any rotation of the ring which may be of such a proper velocity as [might lend some support to the idea of two detached rings].

5 If the southern side of the ring should be differently marked, it would negative the idea of two rings. Even if it should be marked the same in every respect, it would be best to wait for the occultation of some considerable star by *Saturn*, when, if the ring be divided, it will be seen between the openings of the ring, as well as between the ring and *Saturn*.

5 We may certainly affirm that the ring is no less solid than the planet itself. The reasons which prove the solidity of one serve to prove that of the other.

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1790	80	5	The mass of the planet, as determined from the satellites, includes that of the ring; and the ring produces irregularities in the motions of the satellites, as does also the oblateness of the ball of the planet.
		5	The light of the ring is brighter than that of the planet. [Proof given.]
		6	The ring is extremely thin for— 1789, July 18, [*Tethys*] was thicker than the ring; ——, July 23, [*Dione*] was twice as thick as the ring; ——, July 27, [*Enceladus*] was thicker than the ring; ——, August 29, [*Mimas*] was thicker than the ring; 1789, Oct. 15: the ring was barely visible in the 40-foot reflector, but [*Enceladus*] was visible about the middle of the preceding arm. 1789, Oct. 16: I followed [*Mimas* and *Enceladus*] up to the very disc of the planet.
		7	A suspicion arises that by a refraction through some very rare atmosphere on the ring the satellites might be lifted up and depressed so as to be visible on both sides of the ring.
		8	The edge of the ring is very probably not square, but spherical or spheroidical.
		8	The ring cannot possibly disappear on account of its thinness.
		8 9	I formerly supposed the surface of the ring to be rough, owing to luminous points like mountains seen on the ring, till one of these supposed luminous points was kind enough to venture off the edge of the ring and appear as a satellite. As I had noted all such inequalities I could calculate all such surmises, and I have always found these appearances to be due to satellites.
		9	Upon the whole, I cannot say that I had any one instance that could induce me to believe the ring was not of a uniform thickness; that is, equally thick at equal distances from the centre and of an equal diameter throughout.
		10	Strong suspicions of the existence of a sixth satellite I have long entertained. I saw it 1787, August 19. I was then busy with the Georgian satellites.
		10	In 1788 my 20-foot speculum was much tarnished.
		10	The very first moment I turned my 40-foot telescope on *Saturn*, 1789, August 28, I saw six satellites, and on September 17 I detected the seventh satellite.
		11	From many observations of the sixth satellite [*Enceladus*] I find its sidereal revolution $1^d\ 8^h\ 53^m\ 9^s$, and by computation its distance $35''.058$. Its light is considerably strong, but not equal to that of [*Tethys*].
		12	The seventh satellite [*Mimas*] makes one sidereal revolution in $22^h\ 40^m\ 46^s$; its distance (computed) is $27''.366$.
		12	It is incomparably smaller than [*Enceladus*], and even in the 40-foot reflector appears no bigger than a very small lucid point; to which the exquisite figure of the speculum not a little contributes.
		13	The orbits of these two satellites are exactly in the plane of the ring.
		13	Observations of the belts and figure of *Saturn* from April 9, 1775, to Sept. 8, 1780, and reference to [rough] figures are here given.
		15	We may draw two conclusions from these: *First*, *Saturn* has probably a very considerable atmosphere. The changes in the belts show

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this, and also the hanging of the satellites on the limb; the time of hanging on the limb for *Mimas* has actually amounted to 20 minutes. This would denote a refraction of about 2″ [provided, etc.].

1790 80 16 The *second* conclusion is that *Saturn* turns on an axis perpendicular to the ring. The proof depends on the position of the belts which for 14 years have been [nearly] always equatorial.

17 Another reason is that *Saturn*, like *Jupiter*, *Mars*, and the earth, is flattened at the poles, and therefore ought to be supposed to turn on its axis. [Observations 1776, July 22, to 1789, Sept. 14, given.]

On the last date equatorial diameter 22″.81 (4).
polar diameter 20″.61 (4).

18 The equatorial is to the polar diameter nearly as 11 to 10.

18 One beautiful observation of the transit of [*Titan*] over the disc I must add, of 1789, November 2.

WILLIAM HERSCHEL.

[Dated] Slough, near Windsor, November 3, 1789.

1790 80 427 *On the Satellites of the planet Saturn and the rotation of its Ring on an Axis.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read June 7, 1790.

427 The observations to be given extend from July 18 to Dec. 25, 1789. On calculating the appearances of bright luminous points on the ring, I found that all of them could not be accounted for by satellites.

428 The question, then, is, what to make of these protuberant points?

428 To admit two or three more satellites appears too hazardous. And yet a suspicion of at least one more satellite would often return.

428 The observations of each satellite have been separated, and at least one observation of each has been calculated for each night.

429 Fig. 1, Plate XIX, p. 494, gives a scheme of the orbits. Explanation of this figure and of the tables.

432 *Observations on the fifth satellite of Saturn* [*Japetus*].

438 *Observations on the fourth satellite of Saturn* [*Titan*].

441 1789, Nov. 2. Transit of *Titan's* shadow.

444 *Observations on the third satellite of Saturn* [*Rhea*].

447 1789, Oct. 16. The color of *Rhea* is inclining to blue.

450 *Observations on the second satellite of Saturn* [*Dione*].
1789, Sept. 25. Probable occultation of *Dione* by *Tethys*.

456 *Observations on the first satellite of Saturn* [*Tethys*].

463 *Observations on the sixth satellite of Saturn* [*Enceladus*].
1789, Oct. 16. Occultation by *Saturn*.

473 *Observations on the seventh satellite of Saturn* [*Mimas*].
1789, Oct. 16. Occultation by *Saturn*.

478 The motions of these 7 satellites are so well known that no shape of lucid spot, protuberant point, or latent satellite can be occasioned by any one of them without our knowing it. I found that the observations to be given presently could not be explained by any of the known satellites.

478 The first idea was of another satellite interior to the 7th; and if a revolution slower than about 15½ hours could have been found to account for most of the places where the bright spots were seen, I should have believed these to be caused by an 8th satellite. This being impracticable, I examined what would be the result if these bright points were attached to the plane of the ring.

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1790 80 479 As observations, carefully made, should always take the lead of theories, I shall not be concerned if what I have to say contradicts what has been said in my last paper.

479 A lucid and apparently protuberant point may exist without any great inequality in the ring. A vivid light, for instance, will seem to project greatly beyond the limits of the body upon which it is placed.

479 The brightest and best-observed spot agrees to a revolution of $10^h\ 32^m\ 15^s.4$ at a distance of $17''.227$, *i. e.*, on the ring. Therefore, unless the ring is fluid, or has a groove in it, so as to let the satellite revolve in it, we ought to admit a revolution of the ring itself.

480 It seems almost proved that the consistence of the ring is not less than the body of Saturn; consequently no sufficient degree of fluidity can be admitted.

481 *Observations not accounted for by satellites* [are given].

487 Epochs of six of the satellites given.

487 Period of *Enceladus* $1^d\ 8^h\ 53^m\ 8^s.9$; distance $36''.7889$.
" " *Mimas* $0^d\ 22^h\ 37^m\ 22^s.9$; " $28''.6689$.

488 Tables for the seven satellites of Saturn.

495 Example of the use of the tables.

1791 81 71 *On Nebulous Stars, properly so called.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read February 10, 1791.

71 In one of my late examinations of the heavens I discovered *a star of about the 8th magnitude, surrounded with a faintly luminous atmosphere of a considerable extent.*

71 The name nebulous stars was incorrectly used in former times.

71 The milky way itself consists entirely of stars.

72 Nebulæ can be selected so that an insensible gradation shall take place from a coarse cluster like the *Pleiades* down to a milky nebulosity like that in *Orion*, every intermediate step being represented. This tends to confirm the hypothesis that all are composed of stars more or less remote.

73 A comparison of the two *extremes* of the series, as a coarse cluster and a nebulous star, indicates, however, that *the nebulosity about the star is not of a starry nature.*

74 Summary of the reason which formerly led to the belief that all nebulæ were clusters more or less remote.
Basis for the ideas of *connection* and *disjunction* of stars and nebulæ.

75–77 Particular examples of such supposed conjunctions and disassociations. Telescopic milky way of over 60 square degrees.
The trapezium of *Orion* is unconnected with the nebula.

78–82 Notes of observations on nebulous stars and consideration of the relation of the nucleus to the envelope in each case.

83 Considering H, iv 69, [= G. C. 810,] as a typical nebulous star, and supposing the nucleus and chevelure to be connected, we may, 1st, suppose the whole to be of stars, in which case either the nucleus is enormously larger than other stars of its stellar magnitude or the envelope is composed of stars indefinitely small; or, 2d, we must admit that the star is involved in a shining fluid of a nature totally unknown to us.

84 Perhaps it has been too hastily surmised that all milky nebulosity is owing to starlight only.

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The *telescopic milky way* is probably composed of this shining fluid, which must commence somewhere about the range of the stars of the 7th magnitude, and extend to the regions of the 9th, 10th, 11th, and 12th.

1791 81 85 The shining fluid might exist independently of stars. The light of this fluid is no kind of reflection from the star in the center. If this matter is self-luminous, it seems more fit to produce a star by its condensation than to depend on the star for its existence.

86 List of diffused nebulosities and planetary nebulæ; both better accounted for by the hypothesis of a shining fluid than by supposing them to be distant stars.

Regeneration of stars from planetary nebulæ.

87 How far the light-corpuscles emitted from millions of suns may be concerned in this shining fluid it is not necessary to inquire. We need not know the origin of the luminous matter whose existence is rendered evident by means of nebulous stars.

W. HERSCHEL.

[Dated] Slough, January 1, 1791.

1792 82 1 *On the Ring of Saturn and the rotation of the fifth satellite upon its axis.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read December 15, 1791.

1 In a former paper (*Phil. Trans*., vol. lxxx, p. 4) I spoke of the surmise of a division in *Saturn's* ring with proper doubts. My late views of the southern side of the ring and the discovery of its quick rotation enable me to speak decisively.

2 The black division is always of the same breadth if we leave out of account certain very small variations which I have occasionally observed.

3 *Observations on the Ring of Saturn* (from 1790, Sept. 7, to Oct. 24).

4 From these and former observations I think myself authorized now to say that the planet *Saturn* has two concentric rings. * * *

5 The relative dimensions of the rings and spaces are given in a table.

5 This opening in the ring (which is some 2,513 miles in width) must be of considerable service to the planet, in reducing the space that is eclipsed by the shadow of the ring.

6 It becomes a question if both rings revolve in the same time. The period formerly given (*Phil. Trans.*, lxxx, p. 481), belongs to the outer ring. The former observations indicate that the inner ring revolves with great velocity on its axis, but are not sufficient to determine the period.

7 It is quite probable that there should be a small difference in the periods of the two rings.

7 A memoir (in *Histoire de l' Académie Royale des Sciences de Paris*, 1787, p. 249—) refers to observations of many divisions of the ring of *Saturn*.

8 My own observations of *Saturn* since 1774 contain only four where any other black division upon the ring is mentioned than the one I have constantly observed. These 4 observations were in 1780—(see Plate I, figs 1, 2, 3.)

9 *Saturn* was then in the very best situation for viewing the plane of the ring, but I have hitherto set these observations aside as wanting more confirmation.

9 Observations have been made by M. CASSINI, Mr. SHORT, and Mr. HADLEY [and are referred to].

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1792 82 11 It does not appear to me that there is a sufficient ground for admitting the ring of *Saturn* to be of a very changeable nature.

11 Measures of the diameter of the outer ring, reduced to the mean distance of *Saturn* from the earth; 46″.832; 47″.241; 45″.803;

13 *On the rotation of the fifth satellite of Saturn, on its axis.*

The fifth satellite [*Japetus*] is subject to a change of brightness; this having been noticed by other observers I did not at first pay so much attention to it as it deserved. I afterwards followed this satellite with great attention and marked all its changes of apparent brightness.

13 The result of many observations is as follows: The light of the satellite is in full splendor during the time it runs through that part of its orbit, which is between 68 and 129 degrees past the inferior conjunction. In this arc it does not fall above one magnitude short of the brightness of [*Titan*].

14 From about 7° past the opposition till towards the inferior conjunction it is not only less bright than [*Rhea*] but hardly, if at all, exceeds [*Dione*]; or even [*Tethys*] at elongation. Such a change among the fixed stars and to the naked eye would be from the 2d to the 5th magnitude.

14 It is now evident that the time of its rotation on its axis cannot differ much from the time of its revolution about *Saturn;* notwithstanding that the light of the satellite has suffered an occasional change of short duration from other causes.

14 But I may go further and ascertain upon sufficient grounds, that this satellite turns once upon its axis exactly in the time it performs one revolution. This degree of accuracy is obtained by taking in the observations of M. Cassini in *Mémoires de l'Acad. Roy. des Sciences*, 1705, p. 121; (see, also, 1707, p. 96), and those of M. Bernard, *op. cit.*, 1786, p. 378.

16 Joining all these I conclude that the 5th satellite of *Saturn* turns upon its axis once in 79 days 7 hours and 47 minutes.

16 I cannot help reflecting with some pleasure on the discovery of an analogy which shows that a certain uniform plan is carried on among the secondaries of our solar system; and we may conjecture that probably most of the satellites are governed by the same law, especially if it be founded on such a construction of their figure as makes them more ponderous toward their primary planets.

17 From the changes in [*Japetus*] we may conclude that some part of its surface, and this by far the largest, reflects much less light than the rest; and that neither the darkest nor the brightest side of the satellite is turned toward the planet, but partly one and partly the other, though probably less of the bright side.

17 The great regularity of this change of brightness seems to point out another resemblance of this satellite with our moon. We see the spots on the moon of pretty nearly the same brightness, so as not to be overcast in a very strong degree by dense clouds to disfigure them, and therefore have great reason to surmise that her atmosphere is extremely rare; in like manner we may suppose the atmosphere of *Japetus* as rare as that of our moon.

17 *On the distance of the fifth satellite.*

Many measures have been made for the purpose of getting the mass. They begin 1791, Sept. 25, and end Oct. 1.

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1792 82 23 *Miscellaneous observations.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read December 22, 1791.

23 *Account of a Comet.* [1792, I.] This was discovered by CAROLINA HERSCHEL, 1791, Dec. 15. Examined Dec. 16 with a 20-foot reflector; brief description and position for Dec. 16.

24 *On the periodical appearance of o Ceti.*

25 331 days 10^h 19^m is its period.

26 *On the disappearance of the* 55*th Herculis.*

1781, Oct. 10, I examined both 54 and 55 *Herculis;* again 1782, April 11; 1790, May 24, 55 *Herculis* was missing, and although looked for has not again been seen.

27 *Remarkable Phenomena in an eclipse of the Moon.*

1790, Oct. 22, when the moon was totally eclipsed I viewed the disc with a 20-feet reflector with power 360. In several parts of it I perceived many bright, red, luminous points. Most of them were small and round, at least 150 of them. Their light did not much exceed that of *Mons Porphyrites Hevelii.*

We know too little of the surface of the moon to venture at a surmise of the cause from whence the great brightness, similarity, and remarkable color of these points could arise. (Dated) Slough, December 17, 1791.

1793 83 201 *Observations on the Planet Venus.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read June 13, 1793.

201 A series of observations on *Venus* begun in April, 1777, has been continued down to the present time. The first object of the research was to determine the diurnal rotation, for the observations of CASSINI and BIANCHINI can leave no doubt but that it has a rotation on its axis; the second was the atmosphere of *Venus*, of the existence of which, after a few months' observations, I could not entertain the least doubt; and third, the investigation of the real diameter. To which may be added an attention to the construction of the planet with regard to permanent appearances, such as might be ascribed to seas, continents, or mountains.

202 The result of my observations would have been communicated long ago if I had not flattered myself with the hope of some better success concerning the diurnal motion of *Venus*, which has still eluded my constant attention as far as concerns its period and direction.

202 Even at this present time I should hesitate to give the following extracts if it did not seem incumbent upon me to examine by what accident I came to overlook mountains in this planet "*of such enormous height as to exceed four, five, or even six times the perpendicular elevation of Chimboraço, the highest of our mountains.*" [Quoted from SCHROETER, *Phil. Trans.* 1792, p. 337.]

202 The same paper contains other particulars concerning *Venus* and *Saturn.* All of which being things of which I have never taken any notice, it will not be amiss to show by what follows that neither want of attention nor a deficiency of instruments could occasion my not perceiving *these mountains of more than* 23 *miles in height; this jagged border of Venus; and these flat spherical forms on Saturn.*

203 Before I remark on the rest of the extraordinary relations above mentioned I will give a short extract of my observations of *Venus.*

203 *Observations* from 1777, April 17, to 1793, May 20.

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1793	83	204	The observations and drawings (one given in Plate XXII, fig 1), 1780, June 19, 21, 23, 24, 25, 26, 28, 29, 30, and July 3, showed that *Venus* has a motion on her axis, and as evidently that she has an atmosphere.
		206	1789, Nov. 30: no satellite visible; if she has one it must be below 8 or 9 magnitude.
		206	Two measures of the diameter, 1791, Nov. 24.
		215	My observations show that the atmosphere of *Venus* is of much greater extent or refractive power than as given in the paper [of Schroeter.]
		216	As to the mountains in *Venus*, I may venture to say that no eye which is not considerably better than mine, or assisted by much better instruments, will ever get a sight of them.
		217	The diameter of *Venus* at the mean distance of the earth is 18″.79.
		218	The appearance of the luminous border of *Venus* as I have described it, *i. e., suddenly much brighter all around the limb*, has not been noticed by the author we have referred to.
		218	The cause of this appearance may probably be ascribed to the atmosphere of *Venus*, which is probably replete with matter that reflects and refracts light copiously. Therefore on the border, where we have an oblique view, there will be an increase of this appearance.
1794	84	28	*Observations of a quintuple belt on the Planet Saturn.* By William Herschel, LL. D., F. R. S. Read December 19, 1793.
		28	In some of my former papers I have established the spheroidical form of *Saturn* and pointed out the motion of a spot on its disc. From the first we infer a rotation on its axis; the second shows that it has such a motion.
			My late observations seem to hint to us that the period of rotation is not of long duration.
		28	Observations of the quintuple belt; see Plate VI, fig. 1.
		30	Observations of belts on *Jupiter;* see Plate VI, fig. 2, fig. 3.
		31	Belts are connected with the rotation of the planets. Since then it appears that the belts of *Saturn* are very numerous, like those of *Jupiter*, and are also placed in the direction of the longest diameter of the planet, it may not be without some reason that we infer the period of the rotation of the former to be short like that of the latter.
		31	I have never seen parallel belts on *Mars* nor on *Venus*.
1794	84	39	*Account of some particulars observed during the late eclipse of the sun.* [1793, September 5.] By William Herschel, LL. D., F. R. S. Read January 9, 1794.
		39	Observations. See Plate VII, figs. 1, 2, 3.
		39	At first contact two mountains of the moon were seen on the sun; see fig. 1.
		41	The cusps of the sun attentively inspected, and I suspected a little bending of the cusps outward as in fig. 4; but I could not satisfy myself of its reality. If there was a bending, it did probably not amount to 1″.
		41	[Foot-note.] In 1779, 1780, 1781, I measured the heights of about 100 mountains of the moon by three different methods. Some of these observations are given in *Phil. Trans.*, Vol. lxx, p. 507, but most remain uncalculated in my journal till some proper opportunity. Wm. Herschel.
			[Dated] Slough, near Windsor, Dec. 30, 1793.

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1794 84 48 *On the rotation of the planet Saturn upon its axis.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read January 23, 1794.

48 In a late paper I pointed out an analogy which might lead us to surmise that *Saturn* had a quick rotation on its axis. I can at present announce the reality of that rotation by means of observations of 154 revolutions of the planet.

48 The belts of *Saturn* that I have been observing seem to have undergone no material change for the last two months.

48 I give the observations upon which my computations have been founded, entire.

49–59 *Observations on the belts of Saturn.*

50 [Foot-note.] In the course of these observations I made 10 new object specula and 14 small plain ones for my 7-foot reflector, having found that a 7-foot reflector was adequate to my purpose.

51 [Foot-note.] These objectives were from 84 to 88 inches focus, and were used with an eye-glass of $\frac{3}{10}$ of an inch focus, the power thus being from 280 to 293.

52 I took care to bend my head so as to receive the picture of the belt in the same direction upon the retina as I did [formerly].

52 [Foot-note.] This was a precaution that occurred to me, as there was a possibility that the vertical diameter of the retina might be more or less sensible than the horizontal one; but I had no reason afterward to suppose that any such difference really exists.

53 *Observation upon the double ring of Saturn.*

The outer ring is less bright than the inner ring. The inner ring is very bright close to the dividing space; and at about half its breadth it begins to change color, gradually growing fainter.

54 There is a dry wind and the telescope will not show objects as distinct as when moisture is discharged from the air by the precipitation of dew.

55 *Remark on the shadow of Saturn and its rings.*

On the ring is the shadow of the body. The shadow of the ring upon the body of the planet close to the ring is not parallel to the ring at the two extremes, but a little broader there than in the middle, the ends turning toward the south.

56 *The five old satellites* are all seen with a power of 60 on a 10-foot reflector.

57 *Observations of the south pole of Saturn and the shadow of the ring.*

The south polar regions of *Saturn* are a little brighter than they used to be; they are almost as bright as that belt. The shadow of the ring upon Saturn is perfectly black, like the shadow of *Saturn* upon the ring. The shadow of the ring upon *Saturn* on each side is bent a little southward.

58 *Trial of concave eye-glasses.*

With regard to the field of view, they are full as convenient as convex glasses.

59 *Determination of the period of the rotation of Saturn.* Explanation of Plate IX and the method of obtaining the period from the observations.

60 The first trial gives $10^h\ 15^m\ 40^s$ for the time of 1 revolution.

The second trial gives $10^h\ 16^m\ 51^s$ for the time of 1 revolution.

61 The third trial gives $10^h\ 17^m\ 54^s$ for the time of 1 revolution.

The fourth trial gives $10^h\ 17^m\ 6^s$ for the time of 1 revolution.

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1794	84	61	I take the mean of the first two, $10^h 16^m 15^s.5$, for the approximate rotation period.
		62-3	Tables for the motion of the equator of *Saturn*.
		64-5	Comparison of observation with the tables.
		65	We may conclude that the period is exact to $\pm 2^m$, and we need not hesitate to fix the rotation of *Saturn* upon its axis as $10^h 16^m 0^s.4$. WM. HERSCHEL.
			[Dated] Slough, near Windsor, Jan. 22, 1872.
1795	85	46	*On the Nature and Construction of the Sun and Fixed Stars.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read December 18, 1794.
		46	The sun is the celestial body which should first attract our notice, not only on its own account but since the fixed stars are, by the strictest analogy, similar bodies.
		46	NEWTON has shown that the sun retains the planets of our system in their orbits;
		47	BRADLEY has assigned the velocity of the solar light; GALILEO, SCHEINER, HEVELIUS, CASSINI and others have ascertained its rotation and the place of its equator. The Transit of Venus has given means to calculate its distance, its real diameter, magnitude, density, and the fall of heavy bodies on its surface. Thus we have already a clear idea of the powerful influence of the sun.
		47	I should not wonder if [considering what we know] we were induced to think that nothing remained to be added; and yet we are still very ignorant in regard to the internal construction of the sun.
		47	The spots have been supposed to be solid bodies, the smoke of volcanoes, the scum floating on an ocean of fluid matter, clouds, opaque masses, and to be many other things.
		48	The sun itself has been called a globe of fire, though perhaps metaphorically.
		48	The faculæ have been called luminous vapors, etc.
		48	The light of the sun itself has been supposed invisible and not to be perceived except by reflection, though the proofs seem to me to amount to no more than saying that we cannot see when rays of light do not enter the eye. But it is time now to profit by the observations we are in possession of.
		48	I have availed myself of the labors of preceding astronomers, but have been induced thereto by my own actual observation of the solar phenomena.
		49	Following is a short extract of my observations. In 1779 there was a spot on the sun, divided into two parts, the largest above 31,000 miles in diameter. Both together must have extended above 50,000. The idea of its being occasioned by a volcanic explosion ought to be rejected.
		50	We have pretty good reason to believe that all the planets emit light in some degree.
		50	Example of the illumination of the moon during an eclipse, which could not have been due to the light from the earth.
		51	The dark half of *Venus* has been seen by different persons.
		51	In regard to the large spot on the sun, I concluded that I viewed the real solid body of the sun itself, of which we rarely see more than its shining atmosphere.
		51	Description of a large spot seen in 1783: the spot was plainly depressed below the surface of the sun.

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1795 85 51 Explanation of the luminous shelving sides of a sun-spot. The sun may have inequalities [like mountains] on its surface perhaps 500 or 600 miles high.

53 In 1791 I observed a large spot on the sun, depressed below the level of its surface.

53 An optical deception takes place now and then when we view the moon, which is that all the elevated spots on its surface will seem to be cavities, and *vice versa*.

54 How very ill would these observations agree with the ideas of solid bodies bobbing up and down in a fiery liquid? with the smoke of volcanoes or the scum upon an ocean?

54–58 Observations in detail from 1792, Aug. 26, to 1794, Oct. 13.

54 1792, Sept. 2. Two spots on the sun were seen with the naked eye.

55 It may not be impossible, as light is a transparent fluid, that the sun's real surface may also now and then be perceived, as we see the shape of the wick of a candle through its flame.

56 Faculæ seem generally to accompany the spots, and they are certainly elevations on the surface.

57 The sun cannot be so distinctly viewed with a small aperture and faint darkening glasses as with a large aperture and stronger ones.

57 About all the spots the shining matter seems to have been disturbed, and is uneven, lumpy, and zig-zagged in an irregular manner.

57 I call the spots black, not that they are entirely so, but to distinguish them. There is not one of them to-day which is not at least partly covered over with whitish and unequally bright nebulosity.

58 If the brightness of the sun is occasioned by the lucid atmosphere the intensity of the brightness must be less where it is depressed.

The results of these observations are: The sun has a very extensive atmosphere, which consists of various elastic fluids more or less lucid and transparent, and of which the lucid one is that which furnishes us with light.

59 The manner in which I suppose the lucid fluid of the sun to be generated in its atmosphere may be better understood from an analogy drawn from the generation of clouds in our own atmosphere. [This analogy is stated.]

60 That the emission of light must waste the sun is not a difficulty that can be opposed to our hypothesis.

60 Many of the operations of nature are carried on in her great laboratory which we cannot comprehend, but now and then we see some of the tools with which she is at work. [The many telescopic comets may restore to the sun what is lost by the emission of light.]

61 According to my theory a dark spot in the sun is a place in its atmosphere which happens to be free from luminous decompositions, and faculæ are more copious mixtures of such fluids as decompose each other.

62 The penumbra which attends the spots being depressed more or less to about half way between the solid body of the sun and the upper part of the regions where luminous decompositions take place, must of course be fainter than other parts.

62 The regions where the luminous solar clouds are formed, adding thereto the elevation of the faculæ, cannot be less than 1,843 miles nor much more than 2,765 miles.

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1795 85 62 We ought to compare these elevations, not to the clouds of our atmosphere, but to the elevation of the aurora borealis.

62 The density of the solar clouds though very great may not be exceedingly more so than that of the aurora.

62 The opaque body of the sun we know to be of great solidity, and we surmise it to be diversified with mountains and valleys.

63 This way of considering the sun removes the great dissimilarity between its condition and that of the other great bodies of the system. The sun then appears to be nothing else than a very eminent, large, and lucid planet * * * most probably also inhabited by beings whose organs are adapted to the peculiar circumstances of that vast globe.

63 The heat produced by the sun's rays on the earth is so considerable that it may be objected that the surface of the sun must be scorched up beyond all conception.

64 This objection answered by analogies with terrestrial circumstances.

65 I will now show that our moon is probably inhabited.

66 The moon is in many ways analogous to the earth, and to complete the analogy it is only needed that it should be inhabited. To this may be objected that we perceive no large seas there, that its atmosphere is extremely rare, that there is no rain, etc.

66 These objections considered.

67 Suppose an inhabitant of the moon who has not properly considered such analogical reasonings as might induce him to surmise that our earth is inhabited, to give it as his opinion that the use of the earth is to illuminate the moon, when direct daylight cannot be had, etc.

67 Suppose the inhabitants of the moons of *Jupiter*, *Saturn*, and [*Uranus*] to look upon their primary planets merely as so many attractive centers to keep together their orbits, etc., etc.

67 These considerations ought to make the inhabitants of the planets wiser than we have supposed those of their satellites to be. We surely ought not to say "the sun is merely an attractive center to us."

68 That stars are suns can hardly admit of a doubt. The sun turns on its axis; so do variable stars; most probably all stars. Stars have spots like the sun; in some stars we know these spots to be changeable.

68 Analogy may induce us to conclude that each of these stars is accompanied by a group of planets. If these suns themselves are primary planets we may see some thousands of them with our own eyes, and millions by the telescope, while the same analogy remains in regard to the planets which these suns may support.

69 The idea of suns or stars being *merely* the supporters of systems of planets is not to be admitted as a general one.

69 The stars in very compressed clusters are so close that even at a great distance of the cluster there will not be room for the crowding in of those planets for whose support these stars may be supposed to exist.

69 As an instance, I take clusters Nos. 26, 28, and 35 of the VI class, and also very close double stars.

70 Also, in some parts of the milky way the stars are so crowded that in 41 minutes of times no less than 258,000 stars passed through the field of my telescope [in R. A. $19^h\ 35^m$—$20^h\ 12^m$; N. P. D., 73° 54′].

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A. D.	*Vol.*	*P.*	
1795	85	71	It seems, therefore, upon the whole not improbable that in many cases stars are united in such close systems as not to leave much room for the orbits of planets or comets; and that consequently many stars, unless we would make them mere useless brilliant points, may themselves be lucid planets, perhaps unattended by satellites.
		71	*Postscript.* The following observations of the sun are added. They are decisive in regard to one of the conditions of the lucid matter of the sun. 1794, Nov. 26. The sun is mottled everywhere, equally at poles and equator. This is owing to inequalities in its surface.
		71	The lucid substance of the sun is neither a liquid nor an elastic fluid, as is evident from its not instantly filling up the cavities of the spots, etc. It exists, therefore, in the manner of lucid clouds swimming in the transparent atmosphere of the sun; or, rather, of luminous decompositions taking place within that atmosphere.
1795	85	317	*Description of a forty-foot reflecting telescope.* By William Herschel, LL. D., F. R. S. Read June 11, 1795.
		347	When I resided at Bath I had long been acquainted with the theory of optics and mechanics and wanted only that experience so necessary in the practical part of these sciences. This I acquired by degrees at that place, where in my leisure hours by way of amusement I made several 2-foot, 5-foot, 7-foot, 10-foot and 20-foot Newtonian telescopes, besides others of the Gregorian form of 8, 12, 18 inches and 2, 3, 5 and 10 feet focal length.
		348	In this way I made not less than 200 7-foot, 150 more 10-foot, and about 80 20-foot mirrors, not to mention the Gregorian telescopes.
		348	The number of stands I invented for these telescopes it would not be easy to assign. My Newtonian stand was contrived about 1778.
		348	In 1781 I began to construct a 30-foot aërial reflector, and having made a stand for it I cast the mirror 36 inches in diameter, which was cracked in cooling. I cast it a second time, and the furnace which I had built in my house broke. Soon after, the *Georgian Planet* was discovered [and observations on this interrupted the making of new telescopes.]
		349	In 1783 I finished a very good 20-foot reflector, and in 1785 I began to construct the 40-foot.
		349	In the whole of the apparatus none but common workmen were employed, for I made drawings of every part of it and directed every person's labor, though sometimes there were not less than 40 employed at the same time. There was no interruption except my removal from Clay Hall to Slough.
		350	The 40-foot speculum was put into the tube and first used 1787, Feb. 19. The first mirror being too thin, etc., could not receive a good figure, and a second was cast 1788, Jan. 26, which cracked in cooling. It was recast Feb. 16, and on Oct. 24 it had a good figure and I observed *Saturn* with it; but not being satisfied I worked upon it till Aug. 27, 1789. Aug. 28, 1789, I discovered a sixth satellite of *Saturn*. I date the finishing of the telescope from that time.
		350	*Description of the telescope.* See Plates XXIV to XLII.
		350–365	The foundation and stand.
		365	The tube: it is 39 feet 4 inches long, 4 feet 10 inches diameter, made of iron.
		377	Motions of the telescope.

Herschel, W.: SYNOPSIS OF THE WRITINGS OF—Continued.

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1795	85	378	Finder and setting quadrant.
		380	I have in 1789 many times taken up *Saturn* two or three hours before its meridian passage and kept it in view with the greatest facility till two or three hours after the passage, with a single assistant.
		382	The method of observing is by what I have called the front view.
		382	The observing chair is fastened to the instrument.
		383	The aperture of the telescope is 4 feet.
		384	In making sweeps several conveniences are required [as given].
		385	A speaking pipe was led from the observer to the recorder, etc.
		387	Right ascension apparatus.
		390	Polar distance machine: the sidereal clock by SHELTON.
		390	Polar distance piece [described].
		396	In 1783, when I began my sweeps, no catalogue of stars in zones existed. I therefore gave a pattern to my indefatigable assistant, CAROLINA HERSCHEL, who brought all the British catalogue into zones of 1° each from 45 N. P. D. to the horizon, and put the right ascensions in time. This catalogue was afterwards completed to the pole in zones of 5°.
		398	A zone clock described.
		403	The construction of the great mirror is as in fig. 46. The metal is 49½ inches in diameter; 48 inches are polished. Its thickness, which is equal throughout, is 3½ inches; its weight when cast was 2,118 lbs.
		404	It is swung in a ring.
		406	The surface is protected from damp by a tin cover.
		409	Method of mounting the eye-pieces. WM. HERSCHEL. [Dated] Slough, near Windsor, May 18, 1795. *Plates.*
		408	Plate XXIV: General View: "To GEORGE THE THIRD, KING OF GREAT BRITAIN &c. This View of a Forty-Foot Telescope constructed under his Royal Patronage, is with permission, most humbly inscribed, by his Majesty's very devoted and Loyal Subject, and most grateful obedient Servant, William Herschel."
1796	86	133	*Additional observations on the Comet.* [1796, I.] By WILLIAM HERSCHEL, LL. D., F. R. S. [Read November 12, 1795.]
1796	86	166	*On the method of observing the changes that happen to the fixed stars; with some remarks on the stability of the Light of our Sun. To which is added a Catalogue of Comparative Brightness for ascertaining the Permanency of the Lustre of Stars.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read February 25, 1796.
		166	The earliest observers noted the different brilliancy of stars and have classed them into magnitudes. Brightness and [apparent] size were taken as synonymous terms, and may still be used as such, notwithstanding the latter must be a consequence of the former.
		166	If we suppose the stars to be about the size of our sun and at nearly an equal distance from us and from each other, those which form the first enclosure about us will appear brighter than the rest, and there can only be a small number of them.
		166	This hypothesis is nearly confirmed by observation, as may be seen by looking over a globe and applying a pair of compasses opened to 60°. Eleven pairs of 1st mag. stars are about 60° apart.
		167	Eight other pairs are near enough to 60° to support this hypothesis.

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1796 86 167 A second layer of stars will be more extensive, etc., etc.

168 The hypothesis of an equality and an equal distribution of stars is too far from being strictly true to be laid down as an unerring guide.

168 The stars of the 1st and 2d class, scrupulously examined, prove that we must admit them to be either of different sizes or placed at different distances. Both varieties undoubtedly take place.

168 Thus it appears that in the classification of stars into magnitudes there is either no natural standard or none that can be satisfactory.

169 If any dependence could be placed upon the method of magnitudes, it would follow that certain of FLAMSTEED's stars had undergone a change in their lustre. [Examples given.]

170 FLAMSTEED did not compare the stars to each other, but referred each of them separately to its own imaginary standard.

A short inquiry into the confidence to be given to the method of magnitudes may be of considerable use.

170 In FLAMSTEED's observations an error of 1^{m} in the brighter classes and $1\frac{1}{2}^{m}$ in the fainter would hardly deserve attention.

171 In comparing the observations of different astronomers larger errors may be expected.

172 Example. From FLAMSTEED's and LACAILLE's observations of *β Leonis* we may conclude that this star is now less brilliant than formerly.

173 I place each star, instead of giving its magnitude, into a short series [sequence] constructed upon the order of brightness of the nearest proper stars.

174 The Greek letters now affixed to the names of stars do not point out their order of brightness, except for the few brightest stars of each constellation. [Examples.]

175 A doubt may arise whether any succession of brightness might be argued from the very first, second, or third letters of the alphabet, when we find them now arranged thus, as *β α Cassiopeæ*, *β α Cancri*, *γ β Aquilæ*, etc.

177 LALANDE, PIGOTT, and GOODERICKE have used the method I propose in special cases.

178 Simple as my method is in principle, it is very laborious in its progress. I began to use it 14 years ago.

178 My first design was to draw each whole constellation into one series. Accordingly I began, July 16, 1781, to arrange the stars in *Ophiuchus*, thus: α, β, δ, ζ, η, κ, γ, ε. The defect of this arrangement was that we do not always have a proper connection of the steps of the series; the intervals being too great in some cases, too small in others.

178 To get over these difficulties I marked the stars by degrees, three in a magnitude 1′, 1″, 1‴; 2′, 2″, 2‴, etc., as "May 12, 1783; order of the stars in *Boötis* "α 1′, ε 2″, η 2‴, γ β δ 3′, etc."

179 Difficulties with this plan.

180 Other methods tried.

181 The method finally adopted explained. [The method of sequences.]

183 Difficulties in carrying out the method stated.

184 These observations are of importance, as will appear when we remember the great number of alterations of stars which have certainly happened within two centuries.

185 Who would not wish to know the permanency of the lustre of our Sun? If it be allowed to admit the similarity of stars with our sun,

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how necessary will it be to take notice of the fate of our neighboring *suns* in order to guess at that of our own. That *star* which we call the *Sun* may to-morrow begin to undergo a gradual decay of brightness, like *β Leonis*, *α Ceti*, *α Draconis*, *δ Ursæ Majoris*, and many others that will be mentioned in my catalogues.

1796 86 186 It may suddenly increase like the wonderful star in the back of *Cassiopea's* chair, or gradually come on like *β Geminorum*, *β Ceti*, *ζ Sagittarii*, etc.; or it may turn into a periodical star of 25 days' duration, as *Algol* is one of 3 days, *δ Cephei* of 5 days, etc.

186 Perhaps the easiest way of accounting for past changes in our climates is to surmise that our sun has been formerly sometimes more or sometimes less bright than now.

187 A method of ascertaining the quantity or intenseness of solar light might be contrived. Perhaps the thermometer alone might be sufficient.

187 *Introductory Remarks and Explanations of the Arrangement and Characters used in the following Catalogue.*

This *first* catalogue contains 9 constellations; the rest will follow.

190 All the observations have been made in very fine nights when there was no suspicion of any whitish haziness.

191 All observations upon stars of any considerable magnitude have been made with the naked eye.

191 Wherever I have used magnitudes I have adopted Flamsteed's scale.

192 From the numerous differences we have reason to suspect many changes in the lustre of stars since Flamsteed's time.

192 Summary of differences with Flamsteed.

194 I. *Catalogue of the comparative brightness of the Stars.*

212 *Notes.* These contain errata in Flamsteed's atlas and catalogue.

226 Wm. Herschel.

[Dated] Slough, near Windsor, Jan. 1, 1796.

1796 86 452 *On the periodical star α Herculis; with remarks tending to establish the rotatory motion of the Stars on their axes. To which is added a second catalogue of the comparative Brightness of the stars.* By William Herschel, LL. D., F. R. S. Read June 9, 1796.

452 In my first catalogue I announced *α Herculis* as a periodical star. It has been compared with several standard stars but chiefly with ϰ *Ophiuchi*.

453 Table of the variation of light observed in α (Fl. 64) *Herculis*, compared to ϰ (Fl. 27) *Ophiuchi*.

454 The period is about 60 days and a quarter. Greater accuracy can only be obtained by future observations.

455 *On the Rotatory motion of the Stars on their Axes.*

455 We ought not to be satisfied with enrolling the discovery of one more periodical star among the list of facts we are acquainted with; for this would indeed be of no great consequence.

455 Darker spots on the surface of stars will account for all the phenomena of periodic stars so satisfactorily that we certainly need not look out for any other cause. The objections which may be made are: the periods in *Algol*, *β Lyræ*, *δ Cephei*, and *η Antinoi* are short 3, 5, 6, and 7, etc., days; those of *ο Ceti*, the star in *Hydra* and in *Cygnus* are long; 331, 394, and 497 days.

456 Hitherto we have had but 7 periodical stars [some of very short, some

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of very long periods]; the discovery of α *Herculis* as a periodical star with a period of 60 days supplies a link in the chain and removes the objection that arose from the vacancy.

1796 86 456 Another instance of slow rotation is the 5th satellite of *Saturn* [*Japetus*], which revolves on its axis in 79 days.

457 The rotations of the sun, moon, and some of the planets are known by their spots; [*Japetus*] is too small and too distant to allow its spots to be observed. But what we can no longer perceive we can now supply by rational arguments. The change in the light of the satellite proves the rotation; the rotation proves the existence of the spots. A still more extended similarity between the sun and the stars offers itself, by the spots which must also be admitted to take place.

457 There are reasons to surmise that 34 *Cygni* is a periodical star of 18 years' return [see *Phil. Trans.*, 1786, p. 201].

458 When the biography of the stars, if I may be allowed the expression, is arrived to more perfection, we may then possibly not only be still more assured of their rotatory motion, but also perceive that they have other movements, such as nutations of their axes, etc.

458 *Memorandum relating to the following Catalogue.* I find the magnitudes of FLAMSTEED so inconsistent that I shall not continue to note the deviations between my observations and his.

459 II. *Catalogue of the comparative brightness of the Stars.*

477 *Notes.*

WM. HERSCHEL.

[Dated] Slough near Windsor, June 1, 1796.

1797 87 293 *A Third Catalogue of the comparative Brightness of the Stars; with an introductory account of an Index to* Mr. FLAMSTEED's *Observations of the Fixed Stars contained in the second volume of the Historia Cœlestis. To which are added several useful results derived from that Index.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read May 18, 1797.

293 In my earliest reviews of the heavens I found many of the stars of the British Catalogue missing, and took it for granted that they were lost. The deviation of many stars from the magnitudes there given I looked upon as changes in the lustre of the stars. I therefore wished to be able to refer to the original observations upon which the Catalogue was founded, and recommended to my sister the arduous task.

294 She began the work about 20 months ago, and has lately finished it.

294 Description of the manner of making the index.

295 Examples of its use.

293 General results to be obtained from an inspection of the index [with regard to FLAMSTEED's errors].

297 *Additional notes to the stars in the First Catalogue of the comparative brightness of the Stars.*

301 *Same* for the *Second Catalogue.*

307 III. *Catalogue of the comparative brightness of the Stars.*

321 *Notes.*

WM. HERSCHEL.

324 [Dated] Slough, near Windsor, April 12, 1797.

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1797	87	332	*Observations of the changeable Brightness of the Satellites of Jupiter, and of the Variation in their apparent Magnitudes; with a Determination of the Time of their rotatory Motions on their Axes. To which is added a Measure of the Diameter of the Second Satellite, and an Estimate of the comparative size of all the Four.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read June 1, 1797.
1797	87	332	I have, when other pursuits would permit, attended to every circumstance that could forward the discovery of the rotation of the secondary planets. Since I have determined by observation that *Japetus* rotates according to the law obeyed by our moon, it seems natural to conclude that all the secondary planets do the same; consequently, a few good observations that coincide with this theory will go a good way towards confirming it.
		333	I also desired to examine the nature and construction of the satellites. Here phenomena occurred that may be thought remarkable and perhaps contradictory. So far from attempting to lessen the force of such animadversions, I shall be the first to point out difficulties in order that future observations may be made to resolve them.
		334	OBSERVATIONS: *A remarkable Conjunction of two satellites of Jupiter.* II and III cannot be separated with a power of 350 on a 7-foot reflector.
		334	*Intenseness of Light and Color of the Satellites.* I is of a very intense, bright, white, and shining light. It is brighter than II or IV (not larger). IV is inclining to red. It is nearly as bright as II. II is of a dull ash color. III is very white.
		335	*Brightness and diameter distinguished.*
		335	*Diameter of the second Satellite by entering on the Disc of the Planet.*
		339	The *Brightness of the Satellites compared to the Belts and Disk of the Planet.*
		339–342	[Estimates of comparative magnitudes of I, II, III, IV.]
		342	Before we draw any conclusions from these observations, we ought to take notice of the many causes of deception, etc. The method of comparing the brightness is not subject to so great errors as estimating this in terms of an ideal standard. But the situation of the satellites with respect to the planet introduces a new source of error.
		343	Objections to both low and high magnifiers.
		344	It appears that considerable changes take place in the brightness of the satellites, and also a change in their apparent magnitude.
		344	The first fact proves that the satellites have a rotatory motion upon their axes of the same duration with their revolutions about the primary planet. The second either shows that the bodies of the satellites are not spherical, or that some parts of the discs reflect hardly any light.
		345	Discussion of the observations to show that the satellites revolve on their axes in the same time that they revolve about the planet. The observations extend from 1794, July 19, to 1796, November 3.
		346	*Table of the positions of the four satellites at the time of the observations.*
		347	Method of reduction.
		349	Summary of the observations relating to the color of the satellites.
			I is white, but sometimes more intensely so than others.
			II is white, bluish, and ash-colored.
		350	III is always white, but the color is of different intensity in different situations.

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IV is dusky, dingy, inclining to orange, reddish, and ruddy at different times; and these tints may induce us to surmise that this satellite has a considerable atmosphere.

1797 87 350 The diameter of the second satellite is 0″.87 by 1 obs.

351 III is considerably larger than any of the rest; I is a little larger than II, and nearly of the size of IV; II is a little smaller than I and IV, or the smallest of all.

WM. HERSCHEL.

[Dated] Slough, near Windsor, April 30, 1797.

1798 88 47 *On the discovery of four additional satellites of the Georgium Sidus. The retrograde motion of its old Satellites announced, and the cause of their Disappearance at certain distances from the Planet explained.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read December 14, 1797.

47 I have lately recomputed my observations of the satellites of [*Uranus*] with improved tables from 1787 to now. I laid down a set of theorems relating to the motions of these satellites; I calculated tables and devised means for checking the computations.

48 I here announce that the motion of the Georgian satellites is retrograde.

48 From my miscellaneous observations, the existence of four additional satellites will be proved; the observations which tend to ascertain the existence of rings to the planet not being satisfactorily supported, this surmise will be given up, or left till superior instruments are provided.

48 Observations of stars near the planet are given under the head *Reports*, and of the new satellites under the head *Observations.*

49 *Investigation of additional satellites.*

58 *Arguments upon the Reports and Observations.*

An interior satellite. [The observations described.]

62 *An intermediate satellite.* [The observations described.]

63 *An exterior satellite.* [The observations described.]

64 *The most distant satellite.* [The observations described.]

66 The arrangement of the satellites together will be thus:
First satellite, the interior one of Jan. 18, 1790.
Second satellite, the nearest old one of Jan. 11, 1787.
Third satellite, the intermediate one of Mar. 26, 1794.
Fourth satellite, the farthest old one of Jan. 11, 1787.
Fifth satellite, the exterior one of Feb. 9, 1790.
Sixth satellite, the most distant one of Feb. 28, 1794.

67 *Observations and reports tending to the discovery of one or more rings of the Georgian Planet and the flattening of its Polar Regions.*

69 *Remarks upon the foregoing observations.*

70 The observation of the 26th Feb., 1792, seems to be very decisive against the existence of a ring, etc., and I venture to affirm that the planet has no ring in the least resembling those of *Saturn.*

70 The flattening of the poles of the planet seems to be sufficiently ascertained.

71 This being admitted, we may conclude that the *Georgian Planet* also has a rotation on its axis of a considerable degree of velocity.

71 *Reports and observations relating to the light and size of the Georgian satellites, and to their vanishing at certain distances from the Planet.*

73 *Remarks on the foregoing observations.*

73 Small stars near the planet lose much of their lustre.

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1798	88	74	The satellites become regularly invisible at certain distances from the planet.
		76	The first satellite [*Titania*] usually vanishes at 18″. The second satellite [*Oberon*] usually vanishes at 20″. In uncommon and beautiful nights the *first* has once been seen at 13″.8 and the 2d at 17″.3.
		77	A dense atmosphere to the planet would account for this if it were not that the satellites are lost as well in the nearest half of their orbits as in the farthest. A satellite cannot be obscured by an atmosphere that is behind it.
		77	The light of *Jupiter* and *Saturn* is diffused for several minutes [*of arc*] all around them. Their satellites are bright, and having much light to lose they comparatively lose but little. [*Uranus*] is very faint; its satellites are very nearly the dimmest objects that can be seen in the heavens, so that they cannot bear any considerable diminution of their light without becoming invisible.
		78	The distances at which the satellites vanish will show their relative brightness. The first satellite [*Titania*] is rather brighter than the second [*Oberon*]. The interior satellite cannot be much inferior in brightness to these.
		78	*Periodical Revolutions of the New Satellites.* [Dated] Slough, near Windsor, September 1, 1797.
1799	89	121	*A Fourth Catalogue of the Comparative Brightness of the Stars.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read February 21, 1799.
		121	*Catalogue.*
		138	*Notes.* [Dated] Slough near Windsor, Jan. 28, 1799.
1800	90	49	*On the power of penetrating into Space by Telescopes; with a comparative Determination of the Extent of that Power in natural Vision, and in Telescopes of various Sizes and Constructions; illustrated by select observations.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read November 21, 1799.
		49	The power of penetrating into space by telescopes is very different from magnifying power, and ought to be considered separately.
		49	Luminous bodies as here defined are such as throw out light, whatever may be the cause of it, including those that shine by reflection only, and we may distinguish the class of self-luminous bodies when it is necessary.
		50	The question will arise whether luminous bodies scatter light in all directions equally; but until we know more of the powers that emit and reflect light we shall probably remain ignorant on this head.
		50	What I mean to say relates only to the physical points into which we may suppose the surfaces of luminous bodies to be divided. When we consider their whole construction the question assumes another form.
		50	We know from experience that light, flame, and luminous gases are penetrable to the rays of light.
		50	[Foot-note.] An experiment given to prove this.
		51	It follows therefore that every part of the sun's disc cannot appear equally luminous to a given observer on account of the unequal depth of its atmosphere. (See *Phil. Trans.*, 1795, p. 46.)

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1800	90	51	The greatest inequalities in the brightness of luminous bodies will be owing to their natural texture.
		51	Brightness, I ascribe to bodies that throw out light, and those that throw out most are the brightest.
		51	Let the whole quantity of light thrown out by a luminous body be, L; suppose the surface of this body to be composed of N luminous physical points. Let C stand for the mean copiousness of light thrown out from all the physical points of a luminous object. Let c express the copiousness of emitting light of any number of physical points that agree in this respect, and let their number be n; similarly I define c^1 and n^1 for another set of points, and so on. Then $L = cn + c^1n^1 + c^2n^2 +$ etc., and $L \div N = C$.
		52	An objection to this answered.
		52	The brightness of an object is truly defined by CN. The brightness arising from the great value of C may be called the intrinsic brightness; that from the great value of N the aggregate brightness; the absolute brightness is in all cases CN.
		53	In finding an expression for the appearance of luminous objects at any assigned distance we must leave out of account every part of CN which is not applied for the purposes of vision. L representing the whole light thrown out by CN, let l be that part of it used in vision either by the eye or the telescope.
		53	The equation of light, in this sense, is $CN = l$.
		53	The expression for its quantity at the distance of the observer D will be $l \div D^2$.
		53	In natural vision l undergoes a considerable change by the opening or contracting of the pupil of the eye.
		53	In some experiments on light made at Bath in 1780 I [noticed the increased power of vision after staying some time in a dark room].
		53	The opening of the iris is probably not the only cause of seeing better after remaining long in the dark, but the tranquillity of the retina may render it more fit to receive impressions.
		54	This is supported by telescopic vision, for in my sweeps of 4, 5, or 6 hours' duration my eye became so sensitive that when a star of the 3d magnitude came towards the field of view I had to withdraw my eye in order not to injure the delicacy of vision. The opening of the iris was not the cause, as the diameter of the optic pencil was no more than 0.12 inch.
		54	With the 40-foot telescope the appearance of *Sirius* announced itself like the dawn of the morning till this brilliant star at last entered the field of the telescope with all the splendor of the rising sun, and forced me to take my eye from that beautiful sight.
		55	I found the eye, coming from the light, required nearly 20 minutes before it could see delicate objects, and that the view of a star of the 2d or 3d magnitude would so disorder it that nearly the same time was required to reëstablish its tranquillity.
		55	If a is the opening of the iris and A the aperture of the telescope $\frac{a^2L}{D^2}$ is the light admitted by the eye, and $\frac{A^2L}{D^2}$ will be that admitted by the telescope.
		55	Whenever the pencil of light from the telescope is larger than the aperture of the pupil, light is lost. If m be the magnifying power, $A \div m$ ought not to exceed a.

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1800 90 55 Objection to the foregoing. It being proved that an object is equally bright at all distances, it may be urged that in a telescope the different distance of stars can be of no account with regard to their brightness, and that we must consequently be able to see stars which are many thousands of times farther than *Sirius* from us.

56 The origin of such objections is in want of distinction in the two sorts of brightness, which have been discriminated by intrinsic and absolute brightness.

56 The demonstrations of opticians with regard to what I call *intrinsic* brightness, will not oppose what I affirm of *absolute* brightness.

57 Though the sun, to an observer on *Saturn*, must be as bright as it is here on the earth, it cannot be meant that an inhabitant standing on the planet *Saturn* and looking at the sun should *absolutely* receive as much light from it as one on earth receives when he sees it.

57 The picture of the sun on the retina of the Saturnian observer is as *intensely* illuminated as that on the retina of the terrestrial astronomer, but it should be remembered that the sun on *Saturn* appears to be a hundred times less than on the earth; and that consequently, though it may there be *intrinsically* as bright, it must here be *absolutely* an hundred times brighter.

57 This reasoning is entirely applicable to the stars; and the light we can receive from the stars is truly expressed by $\frac{a^2 l}{D^2}$.

58 Hence I am authorized to conclude that stars cannot be seen by the naked eye when they are more than seven or eight times farther from us than *Sirius*, and that they become, comparatively speaking, very soon invisible *with our best instruments.*

58 With respect to the naked eye, the power of penetrating into space is limited. Among reflecting luminous objects our penetrating powers are sufficiently ascertained. An object seen by reflected light at a greater distance than the *Georgian Planet*, it has never been allowed us to perceive.

59 The range of natural vision with self-luminous objects is incomparably more extended, but less accurately to be ascertained.

59 The general supposition is admitted that stars, at least those which seem to be promiscuously scattered, are probably one with another of a certain magnitude.

59 [Foot-note.] The *Phil. Trans.* for the year 1796, page 166, 167, 168 is referred to for support of this assumption.

60 The difference in brightness between *Sirius*, *Arcturus*, *α Cygni*, and *β Tauri*, does not seem to alter the dimensions of the iris; *a*, therefore, becomes a given quantity and may be left out.

61 Admitting that the latter of these stars are probably at double the distance of the former, we can have no other guide to lead us a third step than the before-mentioned hypothesis; in consequence of which it is probable that stars of the third magnitude may be placed about three times as far from us as those of the first.

61 Our third step forward into space may therefore very properly be said to fall on the pole star, on *γ Cygni*, *ε Boötis*, and all those of the same order.

62 The difference between these and the stars of the preceding order is much less striking than that between the stars of the first and second magnitudes. So the calculated ratio of the brightness of a star

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of the sixth magnitude to that of one of the seventh, is but little more than 1⅛ to 1.

1800 90 62 The faintness of the stars of the 7th magnitude gives us little room to believe that we can penetrate much farther into space with objects of no greater brightness than stars.

63 I think, from the faintness of the stars of the 7th magnitude, and from the foregoing considerations, we are authorized to conclude that no star, eight, nine, or at most ten times as far from us as *Sirius*, can possibly be perceived by the natural eye.

63 Where the light of single stars falls short, however, the united lustre of sidereal systems will still be perceived. We easily see the united lustre of the stars in the sword-handle of *Perseus*, though the light of no one of the single stars could have affected the unassisted eye.

64 Perhaps, among the farthest objects that can make an impression on the eye, when not assisted by telescopes, may be reckoned the nebula in the girdle of *Andromeda* discovered by SIMON MARIUS in 1612.

64 It has been shown that brightness or light is to the naked eye truly represented by $\frac{a^2l}{D^2}$; in a telescope, therefore, the light admitted will be expressed by $\frac{A^2l}{D^2}$. Hence it would follow that the artificial power of *penetrating into space* should be to the natural one as A to *a*. But this proportion must be corrected by the practical deficiency in light reflected and transmitted.

65 As the result of many experiments with plane mirrors, polished like my large ones, and of the same composition of metal, I find we shall have, in a telescope of my construction, with one reflection, 63,796 rays, out of 100,000 come to the eye. In the Newtonian form, with a single eye-lens, 42,901; and, with a double eye-glass, 40,681 will remain for vision.

65 Since the brightness of luminous objects is inversely as the squares of the distances, it follows that the penetrating power must be as the square roots of the light received by the eye.

66 In natural vision, therefore, this power is truly expressed by $\sqrt{a^2l}$, and since we have now also obtained a proper correction *x*, we must apply it to the incident light with telescopes.

66 In the Newtonian and other constructions where two specula are used there will also be some loss of light on account of the interposition of the small speculum; therefore, putting *b* for its diameter, we have $\overline{A^2-b^2}$ for the real incident light. This being corrected as above, will give the general expression $\sqrt{xl \times \overline{A^2-b^2}}$ for the same power in telescopes.

66 Then, if we put natural light $l = 1$, and divide by *a*, we have the general form $\frac{\sqrt{x.\overline{A^2-b^2}}}{a}$ for the penetrating power of all sorts of telescopes, compared to that of the natural eye as a standard.

66 In the following investigation we shall suppose $a =$ two-tenths of an inch.

67 "In the year 1776, when I had erected a telescope of 20 foot focal length, of the Newtonian construction, one of its effects by trial was, that when towards evening, on account of darkness, the natural eye could not penetrate far into space, the telescope possessed

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that power sufficiently to shew by the dial of a distant church steeple what o'clock it was, notwithstanding the naked eye could no longer see the steeple itself. Here I only speak of the penetrating power; for though it might require magnifying power to see the figures on the dial, it could require none to see the steeple."

The space-penetrating power of this telescope was 38.99.

1800 90 68–81 [Dimensions of various telescopes used by HERSCHEL, and their calculated space-penetrating powers are given, together with a large number of examples quoted from his note-books illustrative of the relations of magnifying and space-penetrating powers.]

82 Comparison of the space-penetrating power of 20-foot telescope calculated according to the principles developed in this paper with that deduced from observation, as given in *Phil. Trans.*, vol. 75, p. 247, 248. A substantial agreement leads to the conclusion that no single star above 489.551, or at most 612 times as far as *Sirius*, can any longer be seen in this telescope.

83 The space-penetrating power of the large reflector was 192; admitting that stars of the 7th magnitude are visible to the unassisted eye, this telescope would show stars of the 1,342d magnitude. Therefore, a cluster of 5,000 stars might be seen by the 40-foot reflector at a distance at least 300,000 times that of the nearest fixed star.

84–85 The calculated time necessary to sweep the whole heavens with the 40-foot telescope, assuming 100 hours of observing time in the year as the most probable deduction from experience, is 812 years.

[Dated] Slough, near Windsor, June 20, 1799.

1800 90 255 *Investigation of the Powers of the prismatic Colours to heat and illuminate Objects; with remarks that prove the different Refrangibility of radiant Heat. To which is added an Inquiry into the Method of viewing the Sun advantageously with Telescopes of large Apertures and high magnifying Powers.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read March 27, 1800.

255 "It is sometimes of great use in natural philosophy to doubt of things that are commonly taken for granted; especially as the means of resolving any doubt, when once it is entertained, are often within our reach.

256 "In a variety of experiments I have occasionally made relating to the method of viewing the sun, with large telescopes, to the best advantage, I used various combinations of differently coloured darkening glasses. What appeared remarkable was that when I used some of them I felt a sensation of heat, though I had but little light; while others gave me much light, with scarce any sensation of heat. Now, as in these different combinations the sun's image was also differently coloured, it occurred to me that the prismatic rays might have the power of heating bodies very unequally distributed among them; and as I judged it right in this respect to entertain a doubt, it appeared equally proper to admit the same with regard to light. If certain colours should be more apt to occasion heat, others might, on the contrary, be more fit for vision, by possessing a superior illuminating power. At all events, it would be proper to recur to experiments for a decision."

256–260 Eight experiments to test heating power of red, green, and violet regions of the prismatic spectrum.

261 As a result, we have the proportion of the rising of the thermometer in red to that in green as more than 2¼ to 1; in red to violet about 3½ to 1.

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1800 90 262 *Experiments on the illuminating Power of coloured Rays.*

262–270 Ten experiments on the visibility of objects illuminated by differently coloured light.

268 "The maximum of illumination lies in the brightest yellow or palest green."

270 "May not the chemical properties of the prismatic colours be as different as those which relate to light and heat? Adequate methods
271 for an investigation of them may easily be found; and we cannot
too minutely enter into an analysis of light, which is the most subtle
of all the active principles that are concerned in the mechanism of
the operations of nature."

Radiant Heat is of different Refrangibility.

"I must now remark that my foregoing experiments ascertain beyond
a doubt that radiant heat, as well as light, whether they be the
same or different agents, is not only refrangible, but is also subject
272 to the laws of dispersion arising from its different refrangibility;
and, as this subject is new, I may be permitted to dwell a few moments upon it. The prism refracts radiant heat, so as to separate that which is less efficacious from that which is more so. The whole quantity of radiant heat contained in a sunbeam, if this different refrangibility did not exist, must inevitably fall uniformly on a space equal to the area of the prism; and if radiant heat were not refrangible at all, it would fall upon an equal space in the place where the shadow of the prism, when covered, may be seen. But, neither of these events taking place, it is evident that radiant heat is subject to the laws of refraction, and also to those of the different refrangibility of light. May not this lead us to surmise that radiant heat consists of particles of light of a certain range of momenta, and which range may extend a little farther on each side of refrangibility than that of light? We have shewn that in a gradual exposure of the thermometer to the rays of the prismatic spectrum, beginning from the violet, we come to the maximum of light long before we come to that of heat, which lies at the other extreme. By several experiments, which time will not allow me now to report, it appears that the maximum of illumination has little more than half the heat of the full red rays; and, from other experiments, I likewise concluded that the full red falls still short of the maximum of heat, which perhaps lies even a little beyond visible refraction. In this case, radiant heat will at least partly, if not chiefly, consist, if I may be permitted the expression, of invisible light; that is to say, of rays coming from the sun, that have such a momentum as to be unfit for vision. And, admitting, as is highly probable, that the organs of sight are only adapted to receive im-
273 pressions from particles of a certain momentum, it explains why
the maximum of illumination should be in the middle of the refrangible rays, as those which have greater or less momenta are likely to become equally unfit for impressions of sight. Whereas, in radiant heat, there may be no such limitation to the momentum of its particles. From the powerful effects of a burning lens, however, we gather the information that the momentum of terrestrial radiant heat is not likely to exceed that of the sun, and that, consequently, the refrangibility of *calorific* rays cannot extend much beyond that of *colourific* light. Hence, we may also infer that the

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invisible heat of red-hot iron, gradually cooled till it ceases to shine, has the momentum of the invisible rays which, in the solar spectrum viewed by daylight, go to the confines of the red; and this will afford an easy solution of the reflection of invisible heat by concave mirrors."

1800 90 273 *Application of the Result of the foregoing observations to the Method of viewing the Sun advantageously with Telescopes of large Apertures and high magnifying Powers.*

274 Relation of experience which led to investigation.

275–276 Experiments on the absorption of various media.

277 *Telescopic Experiments.*

277–282 Description of twenty-seven experiments to determine the best form of sun-glass for telescopes.

283 Certain precautions to be observed in using telescopes on the sun.

[Dated] Slough, near Windsor, March 8, 1800.

1800 90 284 *Experiments on the Refrangibility of the invisible Rays of the Sun.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read April 24, 1800.

284 Description of method. Three sensitive thermometers were placed upon a small stand upon which a spectrum of the sunlight was caused to fall.

285 Report of first experiment. A thermometer ½ inch beyond limit of visible red rose 6½ degrees in 10 minutes.

286 Report of second experiment. As a result it was "evident that there was a refraction of rays coming from the sun, which, though not fit for vision, were yet highly invested with a power of occasioning heat."

287–288 Experiments at the violet end of the spectrum.

"From these last experiments I was now sufficiently persuaded that no rays which might fall beyond the violet could have any perceptible power, either of illuminating or of heating; and that both these powers continued together throughout the prismatic spectrum, and ended where the faintest violet vanishes."

289–290 Experiments to determine the situation of the maximum of the heating power.

291 "The 5th and 6th experiments show, that the power of heating is extended to the utmost limits of the visible violet rays, but not beyond them, and that it is gradually impaired as the rays grow more refrangible.

"The four last experiments prove, that the maximum of the heating power is vested among the invisible rays; and is probably not less than half an inch beyond the last visible ones, when projected in the manner before mentioned. The same experiments also show, that the sun's invisible rays, in their less refrangible state, and considerably beyond the maximum, still exert a heating power fully equal to that of red-coloured light; and that, consequently, if we may infer the quantity of the efficient from the effect produced, the invisible rays of the sun probably far exceed the visible ones in number.

"To conclude, if we call *light*, those rays which illuminate objects, and *radiant heat*, those which heat bodies, it may be inquired whether light be essentially different from radiant heat? In answer to which I would suggest, that we are not allowed, by the rules of philosophizing, to admit two different causes to explain certain effects, if

they may be accounted for by one. A beam of radiant heat, eman-
ating from the sun, consists of rays that are differently refrangi-
ble. The range of their extent, when dispersed by a prism, begins
at violet-coloured light, where they are most refracted and have
the least efficacy. We have traced these calorific rays throughout
the whole extent of the prismatic spectrum; and found their power
increasing, while their refrangibility was lessened, as far as to the
1800 90 292 confines of red-coloured light. But their diminishing refrangibility
and increasing power did not stop here; for we have pursued them
a considerable way beyond the *prismatic spectrum*, into an invisible
state, still exerting their increasing energy, with a decrease of re-
frangibility, up to the maximum of their power; and have also
traced them to that state where, though still refracted, their energy,
on account, we may suppose, of their now failing density, decreased
pretty fast; after which the invisible *thermometrical spectrum*, if I
may so call it, soon vanished.

"If this be a true account of solar heat, for the support of which I appeal to my experiments, it remains only for us to admit that such of the rays of the sun as have the refrangibility of those which are contained in the prismatic spectrum by the construction of the organs of sight are admitted under the appearance of light and colours; and that the rest, being stopped in the coats and humours of the eye, act upon them, as they are known to do upon all the other parts of our body, by occasioning a sensation of heat."

Explanation of Plate XI, in which is given a view of the apparatus.

[Dated] Slough, near Windsor, March 17, 1800.

1800 90 293 *Experiments on the solar and on the terrestrial Rays that occasion Heat; with a comparative view of the Laws to which Light and Heat, or rather the Rays which occasion them, are subject, in order to determine whether they are the same or different.* By William Herschel, LL. D., F. R. S. Part I. Read May 15, 1800.

"The word heat, in its common acceptation, denotes a certain sensation well known to every person. The cause of this sensation, to avoid ambiguity, ought to have been distinguished by a name different from that which is used to point out its effect. Various authors, indeed, who have treated on the subject of heat, have occasionally added certain terms to distinguish their conceptions, such as latent, absolute, specific, sensible heat, while others have adopted the new expressions of caloric and the matter of heat. None of these descriptive appellations, however, would have completely answered my purpose. I might, as in the preceding papers, have used the name radiant heat, which has been introduced by a celebrated author, and which certainly is not very different from the expressions I have now adopted; but by calling the subject of my researches the rays that occasion heat I cannot be misunderstood as meaning that those rays themselves are heat, nor do I in any respect engage myself to show in what manner they produce heat.

"From what has been said it follows that any objections that may
be alleged from the supposed agency of heat in other circum-
294 stances than in its state of radiance or heat-making rays cannot
be admitted against my experiments. For, notwithstanding I may
be inclined to believe that all phenomena in which heat is con-
cerned, such as the expansion of bodies, fluidity, congelation, fer-

mentation, friction, etc., as well as heat in its various states of being, latent, specific, absolute, or sensible, may be explained on the principle of heat-making rays, and vibrations occasioned by them in the parts of bodies; yet this is not intended at present to be any part of what I shall endeavor to establish.

"I must also remark that in using the word rays I do not mean to oppose, much less to countenance, the opinion of those philosophers who still believe that light itself comes to us from the sun, not by rays, but by the supposed vibrations of an elastic ether, everywhere diffused throughout space. I only claim the same privilege for the rays that occasion heat which they are willing to allow to those that illuminate objects. For, in what manner soever this radiance may be effected, it will be fully proved hereafter that the evidence, either for rays or for vibrations which occasion heat, stands on the same foundation on which the radiance of the illuminating principle, light, is built."

"We shall begin with the heat of luminous bodies in general, such as, in the first place, we have it directly from the sun; and as, in the second, we may obtain it from terrestrial flames, such as torches, candles, lamps, blue-lights, etc.

1800 90 295 "Our next division comprehends the heat of coloured radiants. This we obtain, in the first place, from the sun, by separating its rays in a prism; and, in the second, by having recourse to culinary fires, openly exposed.

"The third division relates to heat obtained from radiants, where neither light nor colour in the rays can be perceived. This, as I have shown, is to be had, in the first place, directly from the sun, by means of a prism applied to its rays; and, in the second, we may have it from fires inclosed in stoves, and from red-hot iron cooled till it can no longer be seen in the dark.

"Besides the arrangement in the order of my experiments which would arise from this division, we have another subject to consider. For, since the chief design of this paper is to give a comparative view of the operations that may be performed on the rays that occasion heat, and of those which we already know to have been effected on the rays that occasion light, it will be necessary to take a short review of the latter. I shall merely select such facts as not only are perfectly well known, but especially such as will answer the intention of my comparative view, and arrange them in the following order: 1. Light, both solar and terrestrial, is a sensation occasioned by rays emanating from luminous bodies, which have a power of illuminating objects; and, according to circumstances, of making them appear of various colours. 2. These rays are subject to the laws of reflection. 3. They are also subject to the laws of refraction. 4. They are of different refrangibility. 5. They are liable 296 to be stopped, in certain proportions, when transmitted through diaphanous bodies. 6. They are liable to be scattered on rough surfaces. 7. They have hitherto been supposed to have a power of heating bodies; but this remains to be examined.

"The similar propositions relating to heat, which are intended to be proved in this paper, will stand as follows: 1. Heat, both solar and terrestrial, is a sensation occasioned by rays emanating from candent substances, which have a power of heating bodies. 2. These rays are subject to the laws of reflection. 3. They are also subject to the laws of reflection. 4. They are of different refrangibility. 5. They are liable to be stopped, in certain proportions, when transmitted through diaphanous bodies. 6. They are liable to be scattered on rough surfaces. 7. They may be supposed, when in a certain state of energy, to have a power of illuminating objects; but this remains to be examined."

1800 90 297 1st Experiment. *Reflection of the Heat of the Sun.*

A thermometer was exposed at the eye end of a ten-feet Newtonian telescope. The rays, after three regular reflections, caused the thermometer to rise 58 degrees. The experiment cannot ascertain whether these rays were those of light or not.

2d Experiment. *Reflection of the Heat of a Candle.*

The ball of a thermometer, placed in the secondary focus of a steel mirror, received 3¼ degrees of heat in five minutes.

298 3d Experiment. *Reflection of the Heat that accompanies the Solar Prismatic colours.*

The same mirror was covered by a piece of pasteboard, which, through
a proper opening, admitted all the visible colors to fall on its pol-
ished surfaces, but excluded every other ray of heat that might be
either on the violet or on the red side, beyond the spectrum. The
299 thermometer in the focus rose 35 degrees above its stationary posi-
tion in the direct red rays when the mirror was covered. "Thus
the prismatic colours, if they are not themselves the heat-making
rays, are at least accompanied by such as have a power of occasion-
ing heat, and are liable to be regularly reflected."

4th Experiment. *Reflection of the Heat of a red-hot Poker.*

300 5th Experiment. *Reflection of the Heat of a Coal Fire by a plain Mirror.*

301 6th Experiment. *Reflection of Fire-heat by a Prism.*

302 7th Experiment. *Reflection of Invisible Solar Heat.*

On a board about 4 feet 6 inches long was placed at one end a small
plain mirror, and at the other two sensitive thermometers. Upon
this board was projected a prismatic spectrum, and just beyond the
limit of the red rays the mirror was stationed so as to reflect invis-
ible rays to the ball of one of the thermometers. In ten minutes
303 this thermometer stood four degrees above the other.

304 8th Experiment. *Reflection and Condensation of the Invisible Solar Rays.*

At the focus of a concave mirror was placed the ball of a thermometer. Upon the mirror was thrown a prismatic spectrum which covered half the mirror. This half was covered by a pasteboard screen so that only invisible rays were reflected to the ball of the thermometer. In one minute the thermometer rose 19 degrees.

305 9th Experiment. *Reflection of Invisible Culinary Heat.*

306–307 10th Experiment. *Reflection of the Invisible Rays of Heat of a Poker, cooled from being red-hot till it could no longer be seen in a dark Place.*

308 11th Experiment. *Refraction of Solar Heat.*

The rays from the sun, falling on the mirror of a Newtonian telescope 24 inches in diameter, were transmitted after reflection through the four lenses of an eye-piece and allowed to fall on the ball of a thermometer.

12th Experiment. *Refraction of the Heat of a Candle.*

309 The image of a candle flame was thrown upon the ball of a thermometer by a lens 1.1 in diameter.

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1800 90 310 13th Experiment. *Refraction of the Heat that accompanies the Coloured part of the Prismatic Spectrum.*

A burning lens 9 inches in diameter was covered by a piece of pasteboard in which there was an opening of a sufficient size to admit all the coloured part of the prismatic spectrum. As the thermometer showed rise of temperature, the conclusions were, that if the coloured rays themselves are not of a heat-making nature, they are at least accompanied with rays that have the power of heating 311 bodies, and that these rays are subject to certain laws of refraction which cannot differ much from those affecting light.

311–312 14th Experiment. *Refraction of the heat of a Chimney Fire.* The same burning glass before the clear fire of a large grate.

313–314 15th Experiment. *Refraction of the Heat of a Red-hot Iron.* This was by a lens of 1.1 inches diameter.

315–316 16th Experiment. *Refraction of Fire-heat by an Instrument resembling a Telescope.*

317 17th Experiment. *Refraction of the Invisible rays of Solar Heat.* The burning lens of 9 inches diameter was half covered by a screen of pasteboard, upon which the prismatic spectrum was thrown, keeping the last visible red colour one-tenth of an inch from the edge of the pasteboard. The thermometer, which had its ball at the focus for red rays, showed great increase of temperature; but at the same time exhibited a slight red colouration. This occasioned a surmise that possibly the invisible rays of the sun might become visible, if they were properly condensed.

318 18th Experiment. *Trial to render the Invisible Rays of the Sun Visible by Condensation.*

The previous experiment was modified so that the last visible red colour was two tenths of an inch from the margin of the pasteboard. Here a marked increase of temperature was evinced without a vestige of light.

319 19th Experiment. *Refraction of Invisible Culinary Heat.*

A heated cylinder of iron was placed on one side of a lens of 1.1 inches diameter, and the ball of a thermometer in the secondary focus on the other side of the lens. A small pasteboard screen was alternately removed from before the thermometer and replaced, the thermometer exhibiting corresponding rise and fall of temperature, from a bright red heat of the cylinder down to its weakest state of black heat.

320–321 20th Experiment. *Confirmation of the* 19th.

322 "As we have now traced the rays which occasion heat, both solar and terrestrial, through all the varieties that were mentioned in the beginning of this paper, and have shown that in every state they are subject to the laws of reflection and refraction, it will be easy to perceive that I have made good a proof of the first three of my propositions. For the same experiments which have convinced us that, according to our second and third articles, heat is both reflexible and refrangible, establish also its radiant nature, and thus equally prove the first of them."

[Dated] Slough, near Windsor, April 26, 1800.

323–326 *Explanation of the Figures.* Plates XII, XII, XIV, XV, and XVI.

1800 90 437 *Experiments on the Solar and on the Terrestrial Rays that occasion Heat; with a comparative View of the Laws to which Light and Heat, or rather the Rays which occasion them, are subject, in order to determine whether* *they are the same or different.* By WILLIAM HERSCHEL, LL. D., F. R. S. Part II. Read Nov. 6, 1800.

"The next three articles of this paper will require, that while we shew the similarity between light and heat, we should at the same time point out some striking and substantial differences, which will
1800 90 438 occur in our experiments on the rays which occasion them, and on which hereafter we may proceed to argue, when the question reserved for the conclusion of this paper, whether light and heat be occasioned by the same or different rays, comes to be discussed."

ART. IV. *Different Refrangibility of the Rays of Heat.*

439 Construction of a curve, from experiments before described, the abscissas of which represent the arrangement of colours in the prismatic spectrum, and the ordinates the corresponding luminous intensity.

440 Construction of a curve which, in a similar manner, represents the distribution of heat in a prismatic spectrum.

"A mere inspection of the two figures, which have been drawn as lying on each other, will enable us now to see how very differently
441 the prism disperses the heat-making rays, and those which occasion illumination. * * * These rays neither agree in their mean refrangibility nor in the situation of their maxima."

441–442 21st Experiment. *The sines of Refraction of the heat-making Rays are in a Constant Ratio to the sines of Incidence.* Ten different refracting angles of various media were used.

443 22nd Experiment. *Correction of the Different Refrangibility of Heat by contrary Refraction in Different Mediums.* An achromatic combination of two crown prisms and one flint deflected no heat outside the visible spectrum.

444 23rd Experiment. *In Burning-glasses the Focus of the Rays of Heat is Different from the Focus of the Rays of Light.*

445 ART. V. *Transmission of Heat-making Rays.*

446–448 Description of apparatus for this investigation.

447 [Foot-note.] Theory of the sensibility of thermometers.

449 *Transmission of Solar Heat through Colourless Substances.*

24th Experiment. The transmission of rays by a piece of bluish-white glass measured.

450 Reference to Table 7 at the end of the paper, which gives the proportion of light transmitted by various substances, solid and liquid, white and coloured.

451 25th Experiment. Transmission through a piece of flint glass ½ inch thick.

452–453 Experiments 26 to 30. Transmission through crown glass, coach glass, Iceland crystal, and two varieties of talc.

453 *Transmission of Solar Heat through Glasses of the prismatic colours.*

453–456 Experiments 31 to 43.

456 *Transmission of Solar Heat through Liquids.*

457–458 Experiments 44 to 49. Transmission through well-water, sea-water, spirits of wine, gin, and brandy.

458 *Transmission of Solar Heat through Scattering Substances.*

458–462 Experiments 50 to 62. Transmission through various pieces of ground glass, an olive-coloured glass, calcined talc, white paper, linen, white persian, and black muslin.

462 *Transmission of Terrestrial Flame-heat through various Substances.*

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1800 90 462–463 Description of apparatus used.

464–470 Experiments 63 to 93. Transmission of heat from a candle flame through the various substances used before.

470 *Transmission of the Solar Heat which is of an Equal Refrangibility with Red Prismatic Rays.*

470–471 Description of apparatus used.

471–476 Experiments 94 to 116. Transmission of red solar rays through the substances used before.

476 *Transmission of Fire-Heat through various Substances.*

476–477 Description of apparatus.

477–485 Experiments 117 to 147. Transmission of heat from a grate fire through the same plates before used.

485 *Transmission of the Invisible Rays of Solar Heat.*

485–490 Experiments 148 to 169.

490 *Transmission of Invisible Terrestrial Heat.*

490–492 Method and apparatus employed.

492–497 Experiments 170 to 194. Transmission of heat from a stove by the plates before used.

497 ART. VI. *Scattering of Solar Heat.*

497–498 Description of apparatus.

499–506 Experiments 195 to 219. Determinations of the amount of heat scattered by various kinds of paper, textile fabrics, metals, &c.

506 ART. VII. *Whether Light and Heat be occasioned by the same or by Different Rays.*

506 "Before we enter into a discussion of this question it appears to me that we are authorized, by the experiments which have been delivered in this paper, to make certain conclusions that will entirely alter the form of our enquiry. Thus, from the 18th experiment it appears that 21 degrees of solar heat were given in one minute to a thermometer by rays which had no power of illuminating objects and which could not be rendered visible, notwithstanding they were brought together in the focus of a burning lens. The same has also been proved of terrestial heat in the 9th experiment, where in one minute 39° of it were given to a thermometer by rays totally invisible, even when condensed by a concave mirror. Hence it is established, by incontrovertible facts, that there are rays of heat, both solar and terrestrial, not endowed with a power of rendering objects visible.

"It has also been proved, by the whole tenour of our prismatic experiments, that this invisible heat is continued, from the beginning of the least refrangible rays towards the most refrangible ones in a series of uninterrupted gradation, from a gentle beginning to a certain maximum, and that it afterwards declines as uniformly to a vanishing state. These phenomena have been ascertained by an instrument which, figuratively speaking, we may call blind, and which, therefore, could give us no information about light; yet, by its faithful report, the thermometer, which is the instrument alluded to, can leave no doubt about the existence of the different degrees of heat in the prismatic spectrum.

"This consideration, as has been observed, must alter the form of our proposed inquiry, for the question being thus at least partly decided, since it is ascertained that we have rays of heat which give no light, it can only become a subject of inquiry whether

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some of these heat-making rays may not have a power of rendering objects visible, superadded to their now already established power of heating bodies."

1800 90 508 "It has been shown that the effect of heat and of illumination may be represented by the two united spectra which we have given." "Now when these are compared it appears that those who would have the rays of heat also to do the office of light must be obliged to maintain the following arbitrary and revolting positions, namely: that a set of rays conveying heat should all at once, in a certain part of the spectrum, begin to give a small degree of light; that this newly acquired power of illumination should increase while the power of heating is on the decline; that when the illuminating principle is come to a maximum it should in its turn also decline very rapidly and vanish at the same time with the power of heating. How can effects that are so opposite be ascribed to the same cause?"

509 Relation of the refrangibility of the maximum heat-making rays and that of the rays of maximum luminousity.

TABLE I.—Containing the results of experiments 24 to 30.

510 TABLE II.—Containing the results of experiments 31 to 43, followed by a discussion of the same.

511 TABLE III.—Results of experiments on liquids.

511 TABLE IV. Containing the stoppages occasioned by scattering substances.

512–519 Argument founded upon the data contained in these four tables. The general course of this argument is that, assuming the heat-making rays and rays of light to be of the same nature, a ratio of the efficacy of the invisible rays to that of the luminous rays derived from one set of experiments is incompatible with the ratio derived from any other set. Under the assumption that the heat-making rays are essentially different from light rays, this incompatibility does not appear.

520 TABLE V. *Stoppage of Prismatic Heat of the Refrangibility of the Red Rays, and of the Invisible Rays.*

[The measurements on dark-red glass here quoted is HERSCHEL'S decisive experiment, proving that heat-making rays are not the same by nature as the light rays. The experiment involves a photometric determination not described, the result of which is, however, quoted.]

521–523 Argument founded upon data in above table.

524 TABLE VI. Containing the results of the experiments on the transmission of terrestrial heat.

525–527 Showing the impossibility of explaining these results by any assumption as to the ratio of the efficacy of visible and invisible rays.

528 *Table of the Transmission of Terrestrial Scattered Light through various Substances; with a short Account of the Method by which the Results contained in this Table have been obtained.*

528–531 Description of the method and apparatus used, both being founded upon the principles of BOUGUER. The sources of scattered light were vanes of white paper illuminated by a lamp.

532–533 TABLE VII. This table contains the transmitting power for light of nearly all the substances used in the experiments of this paper.

533 *Table of the Proportional Terrestrial Light Scattered by various Substances.*

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1800	90	533–534	Method of determination.
		534–535	Table VIII. Containing the relative scattering power of thirty-three bodies.
		535–538	*Explanation of the Plates.*
1801	91	265	*Observations tending to investigate the Nature of the Sun in order to find the Causes or Symptoms of its variable Emission of Light and Heat; with Remarks on the Use that may possibly be drawn from Solar Observations.* By William Herschel, LL. D., F. R S. Read April 16, 1801.
		265–266	Reference to Herschel's view, given on a former occasion, that the sun is a magnificent habitable globe; declaration that these more recent observations support that view; and a statement as to the importance of solar observations in their bearing upon the climate, together with an opinion that such observations will enable us to predict the character of a season.
		267–268	Definitions of the terms, *openings, shallows, ridges, nodules, corrugations, indentations, and pores.*
		269	Explanation of the form of the paper and the reasons for it.
		270	Of openings. *Openings are Places where the luminous Clouds of the Sun are removed.*
			[Foot-note.] For a geometrical proof of the depression of openings a reference to a paper by Alexander Wilson, *Phil. Trans.*, vol. 64.
		271	*Large Openings have generally Shallows about them. Many Openings are without Shallows. Small Openings are generally without Shallows. Openings have generally Ridges and Nodules about them.*
		272	*Openings have a Tendency to run into each other. New Openings break out near other Openings. Probable Cause of Openings.*
		273	*Direction and Operation of the disturbing Cause.*
		274	*Maxima of Openings.*
		275	*There is some Difference in the colour of Openings. Openings divide when they are decaying.*
		276	*Decaying Openings sometimes increase again. When Openings are divided they grow less and vanish. Decayed Openings sometimes become large Indentations.*
		277	*Decaying Openings turn sometimes into Pores. When Openings are vanished, they leave Disturbance behind.*
		278	*Apparent View into the Openings, under luminous Ridges and Shallows. Depth of the Openings indicated by their Darkness.*
		279	*Distance between the Shallows and solar Surface, indicated by the free Motion of low Clouds.*
		280	Of Shallows. *Shallows are depressed below the general Surface of the Sun; and are Places where the luminous solar Clouds of the upper Regions are removed. The Thickness of the Shallows is visible.*
		281	*Sometimes there are Shallows without Openings in them. Incipient Shallows come from the Openings, or branch out from Shallows already formed, and go forwards. Probable Cause of Shallows.*
		283	*Shallows have no Corrugations, but are tufted. Decay of Shallows.*
		283	Of Ridges. *Ridges are Elevations above the general Surface of the luminous Clouds of the Sun.*
		284	*Length of a Ridge. Ridges generally accompany Openings. Ridges are also often in Places where there are no Openings.*

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1801 91 285 *Ridges disperse very soon. Different Causes of Ridges hinted at.*

286 OF NODULES. *Nodules are small, but highly elevated, luminous Places. Nodules may be Ridges fore-shortened.*

287 OF CORRUGATIONS. *Corrugations consist of Elevations and Depressions. Corrugations extend all over the Surface of the Sun.*

288 *Dispersed Ridges or Nodules make Corrugations. Corrugations change their Shape and Situation; they increase, diminish, divide, and vanish quickly.*

289 OF INDENTATIONS. *The dark places of Corrugations are Indentations.*

290 *Indentations are without Openings. In some places the Indentations contain small Openings. The Elevations and Indentations of Corrugations are of different Figures. Indentations change to Openings.*

291 *Indentations are of the same Nature as Shallows. Indentations are low Places, which often contain very small Openings. Indentations are of different Sizes. Indentations are extended all over the Sun.*

292 *With low magnifying Powers, Indentations will appear like Points.*

292 OF PORES. *The low places of Indentations are Pores. Pores increase sometimes, and become Openings. Pores vanish quickly.*

293 OF THE REGIONS OF SOLAR CLOUDS.

Changes in the Solar Clouds happen continually.

294 *There are two different Regions of Solar Clouds.*

The inferior clouds are opaque, and probably not unlike those of our Planet.

295 *Quantity of light reflected from the inferior Planetary Clouds.*

297 *Indentations are planetary Clouds, reflecting light through the open Parts of the Corrugations. The opaque inferior Clouds probably suffer but little of the light of the self-luminous superior Clouds to come to the Body of the Sun. Motion of the inferior Clouds.*

298 *Motion of the superior Clouds.*

299 *Eminent Use of the planetary Clouds.*

300 OF THE SOLAR ATMOSPHERE. *The Sun has a planetary Atmosphere. The Sun's planetary Atmosphere extends to a great Height. The planetary Atmosphere of the Sun is of great Density.*

301 *The Solar Atmosphere, like ours, is subject to Agitations, such as with us are occasioned by Winds. There is some clear Atmospheric Space, between the solid Body of the Sun and the lowest Region of the Clouds.*

302 *The Sun's planetary Atmosphere is transparent.*

303 THEORETICAL EXPLANATION OF THE SOLAR PHENOMENA.

GENERATION OF PORES.

304 *Formation of Corrugations. Cause of Indentations.*

305 *Cause of the mottled Appearance of the Sun. Formation of small Openings, Ridges, and Nodules. Production of large Openings and Shallows.*

306 SIGNS OF SCARCITY OF LUMINOUS MATTER IN THE SUN.

Visible Deficiency of empyreal Clouds. A perfect Calm in the upper Regions of solar Clouds. Want of Openings, Ridges, and Nodules.

307 *Many Indentations without, and others with, changeable Pores.*

308 SIGNS OF ABUNDANCE OF LUMINOUS MATTER IN THE SUN.

Visible Increase of empyreal Clouds. Many Openings, Ridges, and Nodules.

310 *Coarse and luminous Corrugations.*

[Each of the above headings is followed by quotations from HERSCHEL'S Journals in confirmation].

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1801 91 310–318 A general discussion of the conclusions to be deduced from the observations quoted in this paper. [To HERSCHEL it seemed that the absence of Openings, Ridges, and Nodules, indicated a scarcity of luminous matter in the sun, and, therefore, that the seasons during which such conditions of the sun were recorded ought to be of a lower temperature. He finds support for this view in the higher price of wheat during the five recorded periods of scarcity of sun spots.]

318 Explanation of the 1st, 2d, 11th, and 12th figures of Plates XVIII and XIX.

1801 91 354 *Additional Observations tending to investigate the Symptoms of the variable Emission of the Light and Heat of the Sun; with Trials to set aside darkening Glasses, by transmitting the Solar Rays through Liquids; and a few Remarks to remove Objections that might be made against some of the Arguments contained in the former Paper.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read May 14, 1801.

354–355 Considerations as to the relations of the condition of the solar surface and the weather.

355 "Before I proceed, I must hint to those who may be willing to attend to this subject, that I have a strong suspicion that one half of our sun is less favorable to a copious emission of rays than the other; and that its variable lustre may possibly appear to other solar systems, as irregular periodical stars are seen by us; but, whether this arises from some permanent construction of the solar surface, or is
356 merely an accidental circumstance, must be left to future investigation: it should, however, be carefully attended to."

356–361 *Observations of the sun.*

361 Description of a skeleton eye-piece, into the vacancy of which may be placed a moveable trough, shut at the ends with plain glasses, so that the sun's rays may be made to pass through any liquid, such as spirits of wine, Port wine, mixture of ink and water, etc., placed in the trough.

362 EXPLANATION OF THE FIGURES. Plate XXVIII.

1802 92 213 *Observations on the two lately discovered bodies.* [Ceres and Pallas.] By WILLIAM HERSCHEL, LL. D., F. R. S. Read May 6, 1802.

213 [*Ceres*] is of very small size. [Foot-note.] Its real diameter is not as great as three-eighths of our moon.

214 *Magnitude of the new Stars.* [*Ceres* and *Pallas.*]

April 1, 1802. I placed a lucid disc at a considerable distance from the eye and viewed with one eye the magnified star (seen with a 7-foot reflector) and the lucid disc with the other.

215 By this means it appears that the real diameter of *Ceres* is not above 0″.40.

215 April 21. With a ten-foot reflector the same experiment gave 0″. 38.

217 April 22. For *Ceres* the diameter was 0″.22. For *Pallas* 0″.17 and 0″.13.

218 The real diameters are, then, *Ceres* 161.6 miles, *Pallas* 147 miles.

219 *Of Satellites.* [Observations on this subject.]

220 There is certainly no satellite to *Ceres* that can be seen with the 20-foot reflector.

220 *Of the Color of the new Stars.* The color of *Ceres* is ruddy but not very deep. *Ceres* is more ruddy than *Pallas*. *Pallas* is of a dusky whitish color.

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1802	92	221	*Of the Appearances of the new stars with regard to a Disk.*
			Ceres has a visible disk. *Pallas'* disk I would rather call a nucleus.
		221	*Of the appearances of the new stars, with regard to an atmosphere or coma.*
			[Observations] probably no coma.
		223	*On the nature of the new Stars.*
		223	What are these new stars; are they planets or are they comets?
		224	Planets defined (by 7 particular properties).
		225	Our new stars cannot be called planets.
		226	Comets defined (by 5 particular properties).
		228	The new stars are not comets. They should be called *Asteroids* from their resemblance to small stars.
		229	Asteroids defined.
		229	Statement of the reasons we have for expecting that additional asteroids may probably be soon found out.
		229	I have already made five reviews of the zodiac without detecting any of these asteroids; their motion and not their appearance will be the future means of detecting them.
		230	We have reason to believe that a number of asteroids may remain concealed.
		230	Comets may become asteroids.
		231	*Additional observations relating to the appearances of the asteroids Ceres and Pallas.*
			The coma of *Ceres* not much greater than that of stars of the same magnitude.
		232	The fixed stars differ considerably in this respect among themselves.
		232	The coma of *Pallas* not much more than for equal fixed stars.
1802	92	477	*Catalogue of* 500 *new Nebulæ, nebulous Stars, planetary nebulæ and Clusters of Stars; with Remarks on the construction of the Heavens.* By William Herschel, LL. D., F. R. S. Read July 1, 1802.
			After a sufficient number of celestial objects is found, there is a necessity for a scientific classification. The former classification was only for the convenience of the observer.
		478	ENUMERATION OF THE PARTS THAT ENTER INTO THE CONSTRUCTION OF THE HEAVENS.
			I. *Of Insulated Stars.*
		479	Notion of an insulated star—our sun is one.
		480	The milky way consists of stars very differently scattered from those which are immediately about us.
		480	By analogy we may admit that every insulated star may be attended with planets, etc. I should hesitate to extend this analogy to every star in the heavens, and even think that probably we can only look for solar systems among insulated stars.
		480	II. *Of Binary Sidereal Systems or Double Stars.*
		481	Difference between a double and a binary star.
		482	Difference between solar and sidereal systems.
		482	No insulated stars of nearly an equal size and distance can appear double to us.
		483	Proof of this.
		485	Casual situations will not account for the multiplied phenomena of double stars, and their existence is owing to a general law of nature—gravitation is that law.
		486	I shall soon communicate a series of observations on double stars, proving that *many of them have already changed their situation with*

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regard to each other in a progressive course, denoting a periodical revolution round each other.

Our sun does not belong to such a system.

III. *Of more complicated Sidereal Systems, or treble, quadruple, quintuple, and multiple stars.*

1802 92 487 Theorem as to the permanent connection of revolving stars, when the forces acting on any one of them reduced to a direction as coming from the empty centre are in the direct ratio of the distances from that centre.

488–494 Hypothetical examples of such multiple stars.

494 Such combinations as I have mentioned are not the inventions of fancy; they have an actual existence; and, were it necessary, I could point them out by thousands.

495 I do not imagine that I have pointed out the actual manner in which they are held together, but only the possibilities of such unions.

495 IV. *Of Clustering Stars and the Milky Way.*

Marks of clustering in the milky way. Example of the stars between *β* and *ζ* Cygni.

496 "We may indeed partly ascribe the increase, both of brightness and of apparent compression, to a greater depth of the space which contains these stars; but this will equally tend to show their clustering condition, for since the increase of brightness is gradual, the space containing the clustering stars must tend to a spherical form if the gradual increase of brightness is to be explained by the situation of the stars."

V. *Of groups of Stars.* Definition.

497 VI. *Of clusters of Stars.* Definition.

VII. *Of Nebulæ.* Perhaps they are all to be resolved into the three last-mentioned species.

498 Power of a telescope to penetrate not only space but time past.

499 VIII. *Of Stars with Burs or Stellar Nebulæ.*

IX. *Of Milky Nebulosity.*

Probably of two kinds. 1st, apparent, which is formed by distant ["widely-extended"] clustering stars; and, 2d, real, and possibly at no very great distance from us. The nebula of *Orion* of this latter kind.

500 X. *Of Nebulous Stars.*

501 XI. *Of Planetary Nebulæ.*

Perhaps they are allied to nebulous stars.

XII. *Of Planetary Nebulæ with Centres.*

503 Catalogue.

Class I	No. 216	to	No. 228
II	No. 769	to	No. 907
III	No. 748	to	No. 978
IV	No. 59	to	No. 78
V	No. 45	to	No. 52
VI	No. 36	to	No. 42
VII	No. 56	to	No. 67
VIII	No. 79	to	No. 88

528 Plates XVI and XVII, 16 figures of hypothetical orbits of multiple stars.

1803 93 214 *Observations of the Transit of Mercury over the disk of the Sun; to which is added an investigation of the causes which often prevent the proper*

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action of Mirrors. By WILLIAM HERSCHEL, LL. D., F. R. S. Read February 10, 1803.

1803 93 214 The observations were made (1802, Nov. 9) with a *glass* mirror of 7 feet focus and 6.3 inches aperture under favorable conditions, and

215 also with a 10-feet reflector. Eye-pieces made of dark-green glass and others smoked on the side next the eye were used.

216 No ring about the planet; no distortion of the limbs of the sun or *Mercury* at egress.

217 *Mercury* was perfectly spherical in figure.

217 *Observations and experiments relating to the causes which often affect mirrors, so as to prevent their showing objects distinctly.*

217 The experience of many years will enable me to assign the principa causes of disappointments in the use of mirrors.

218 The following observations have all been made with specula of undoubted goodness, so that every cause which impeded their proper action was extrinsic.

218 *Moisture in the air.* Damp air is no enemy to vision.

219 *Fogs.*

220 *Frost.*

221 *Hoar-Frost; Dry-Air.*

222 *Northern-Lights; Windy-Weather; Fine in Appearance.*

223 *Over a Building; The Telescope lately brought out.*

224 *Confined Place; Haziness and Clouds.*

225 *Focal-length.*

226 In order to see well with telescopes it is required that the temperature of the atmosphere and mirror should be uniform and the air fraught with moisture.

All the preceding observations are accounted for by this principle.

228 Experiments [on the effects of change of focal length of a speculum.] Heat applied back and front of a glass speculum lengthened the focus.

230 With a metal mirror the focus became first shorter and then lengthened.

231 In observing the sun similar effects may arise.

232 Perhaps these might be counteracted by an application of heat to the back of the mirror or by an interception of it in front.

1803 93 339 *Account of the changes that have happened during the last Twenty-Five Years in the Relative Situation of Double-Stars; with an investigation of the Cause to which they are owing.* By WILLIAM HERSCHEL, LL.D., F. R. S. Read June 9, 1803.

339 In *Phil. Trans.*, 1802, p. 477, I have defined insulated stars. The discovery of [*Ceres* and *Pallas*] has enlarged our knowledge of the system of insulated stars.

340 I have already shown that two stars may revolve about their common centre of gravity; and that it is probable there would be many such binary systems among all the stars of the heavens. But neither of these reasons is a proof of the actual existence of such systems. I will here give an account of observations which will go to prove that many of them are not merely double in appearance, but are real binary combinations, intimately held together by the bond of mutual attraction.

341 In Plate VII, Fig. 1, call the place of the sun, O, of the larger star of a double star, α, of the smaller, χ.

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1803	93	341	There are three motions to be considered of the bodies O, α, χ; a motion of one, of two, or of all three.
		341	*Single Motions.* If α and O are at rest, a motion of χ may be assumed so as perfectly to explain any change of distance or of angle of position of the two stars.
		342	The effect of a motion of α or of O explained.
		343	*Double motions.*
		344	*Motions of the three bodies.*
		345	[Observations] case of *α Geminorum.* The distance has remained about constant for 23¼ years.
		345	In a reflector the apparent diameter of a star depends upon: the aperture with respect to the focal length; the distinctness of the mirror; the magnifying power; the state of the atmosphere. By contracting the aperture we can increase the apparent diameter; want of distinctness does the same thing; an increase of magnifying power increases the distance apart of two stars, but this increase is not proportional to the increase of the power, and sooner or later comes to a maximum; the state of the atmosphere is the most material condition, as we cannot alter it.
		346	The other three causes are at our disposal. I took ten different mirrors of 7 feet focus, 6.3 inches aperture, magnifying power 460. With these, one after another, I viewed *α Geminorum.* With each one the distance of the components was the same.
		346	When double stars are first seen they appear nearer together than later.
		347	I have known it to take up two or three months before the eye was sufficiently acquainted with the object to judge with the requisite precision.
		347	The error of this method of estimating the distance of these two stars is not above $0''.34$.
		348	The angle of position of these stars was in 1779, 32° 47′ north-preceding; it is now only 10° 53′. In 23¼ years it has diminished 21° 54′; this change has been regular and gradual.
		348	Accuracy of the angles of position investigated by the deviation of separate measures from the mean.
		349	This micrometer, then, will give the position of a double star true to about 1° from 2 measures; in the worst circumstances the error will not be 3°.
		350	The cause of this change must be examined. A revolving star would explain the alteration of the angle of position with no alteration of the distance. As we have no precedent for, this it will be right to examine whether the change cannot be accounted for by the proper motions of the stars, or of the sun.
		350	*Single motions* [examined].
		355	All are inconsistent with my observations.
		356	The proper motion of the sun must be admitted in such a direction and of such a velocity as will satisfy the mean direction and velocity of the general proper motions of the stars.
		356	*Double Motion.* This hypothesis is not maintainable.
		359	*Motion of the three Bodies.* This hypothesis will explain the observations, but in so complex a way as to leave no doubt that we should give the preference [to the hypothesis of a revolution of the stars themselves].

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1803 93 362 Table of measures of *Castor* and comparison of calculated and observed angles.

363 An observation of BRADLEY'S on *Castor* (1759) quoted.

365 New table of calculated and observed angles, including BRADLEY'S observations. The arc 45° 39′ has been described in 43 years 142 days.

365 The regularity of the motions gives us reason to conclude that the orbits of these stars are circular and at right angles to the line of sight; if this be nearly true the time of a revolution will be about 342 years and 2 months.

366–372 *γ Leonis.* [This case considered as before.]

372 Table of observations: the period is about 1,200 years.

372 *ε Boötis.*

378 *ζ Herculis.*

380 *δ Serpentis.*

381 *γ Virginis.*

382–3 Plates VII and VIII—figures of orbits.

1804 94 353 *Continuation of an Account of the Changes that have happened in the relative situation of double Stars.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read June 7, 1804.

353 In my former paper (*Phil. Trans.*, 1803, p. 339) I gave the changes in the situation of six double stars.

353 I used the best observations I had of the position of *Castor*, but as the proper motions of 36 principal stars published in the Greenwich observations give the motion of this star different from what I used, it will be necessary to review the arguments in the same order as in the preceding paper.

358 [The former conclusions in regard to *Castor* are confirmed.]

359 In the further list of 50 double stars here given, 28 have undergone only moderate changes, less than 10°.

Thirteen have altered their situation above 10° but less than 20°; 3 stars have changed more than 20°; the six remaining have changed between 30° and 130°.

359–384 [The various pairs considered and observations given.]

360 I have no longer supposed the solar motion to be directed to *λ Herculis*, but to a point at no very great distance from this star.

1805 95 31 *Experiments for ascertaining how far Telescopes will enable us to determine very small Angles, and to distinguish the real from the spurious Diameters of celestial and terrestial Objects; with an Application of the Result of these Experiments to a Series of Observations on the Nature and Magnitude of* MR. HARDING'S *lately discovered Star.* [*Juno.*] By WILLIAM HERSCHEL, LL. D., F. R. S. Read December 6, 1804.

31 "We know that a very thin line may be perceived and that objects may be seen when they subtend a very small angle; but the case I wanted to determine relates to a visible disk, a round, well-defined appearance, which we may without hesitation affirm to be circular, if not spherical."

[In 1774 HERSCHEL found that a square area could not be distinguished from an equal circular one till the diameter of the latter came to subtend an angle of 2′ 17″.]

32 1st Experiment, *with the Heads of Pins.*

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1805 95 33 These objects were observed at a distance of 2407.85 inches from the mirror of a ten-feet reflecting telescope. It was found that in the telescope a body subtending the magnified angle of 2′ 19″ could easily be recognized as round.

2d Experiment, *with small Globules of Sealing-wax.*

34 It appeared that with a substance not reflecting much light the magnified angle must be between 4 and 5 minutes before we can see it round.

35 3d Experiment, *with Globules of Silver.*

36–57 4th Experiment, *with Globules of Pitch, Bees-wax, and Brimstone.*

38–39 5th Experiment, *with Objects at a greater Distance.*

40 6th Experiment, *with illuminated Globules.*

40 SPURIOUS DIAMETERS OF CELESTIAL OBJECTS.

Observations and Experiments, with Remarks.

41 With stars, the spurious diameters are larger than the real ones, which are too small to be seen.

The spurious diameters of stars are of different sizes, and under the same circumstances their dimensions are of a permanent nature.

The spurious diameters of the stars are differently coloured.

42 Their spurious diameters are lessened by increasing the magnifying power, but in a much less ratio.

Magnifying power acts less on the large diameters and more on the small ones. When the aperture of the telescope is lessened, it will occasion an increase of the spurious diameters; but this increase is not proportional to the diameters of the stars, acting more upon the 43 small spurious diameters and less upon the large ones. Very small stars, however, lose their spurious diameters, and become nebulous.

The spurious diameter of a star is reduced by haziness of the atmosphere. At a low altitude a star makes a spectrum, being coloured by the prismatic power of the atmosphere.

44 SPURIOUS DIAMETERS OF TERRESTRIAL OBJECTS, WITH SIMILAR REMARKS.

7th Experiment *with Silver Globules.*

45 8th Experiment.

The luminous spots or spurious disks of the globules were of unequal diameters.

9th Experiment. 10th Experiment.

46 11th Experiment. 12th Experiment.

47 13th Experiment. 14th Experiment.

48–49 15th Experiment, *with Drops of Quicksilver.*

50 [These experiments, from the 7th to the 15th, inclusive, prove that all the remarks made concerning the spurious disks of stars are also applicable to sufficiently small and bright terrestrial objects.]

16th Experiment, *with black and white Circles.*

51 17th Experiment, *with different Illumination.*

18th Experiment. *Measures of spurious Disks.*

With drops of quicksilver, the spurious disks were measured by means of distant disks of known diameters upon which they were projected. By covering the mirror with screens of different apertures, and also 52 by stopping out its center by circular screens of different size, it was found that the sizes of the spurious disks were not determined by the quantity of light reflected from the mirror, but rather by the

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1805 95 53 part of the mirror used. Thus the inside rays of a mirror increase the diameter of these disks, whereas the outside rays alone have a greater effect in reducing it than they do when the inside rays are left to join with them. This affords a criterion as to whether a disk is real or spurious.

19th Experiment. *Trial of Estimations.*

20th Experiment. *Use of the Criterion.*

54 21st Experiment. *Measures of the comparative Amount of the spurious Diameters produced by the Inside and Outside Rays.*

22d Experiment. *Trial of the Criterion on celestial Objects.*

55 22d Experiment. [Another trial.]

55–61 OBSERVATIONS ON THE NATURE AND MAGNITUDE OF MR. HARDING'S LATELY-DISCOVERED STAR.

61 RESULTS AND APPLICATION OF THE EXPERIMENTS AND OBSERVATIONS.

62 There is a limit to the size of objects [½ second in HERSCHEL'S 10-foot telescope] above which a mere increase in magnifying power will betray the real disk. By the criterion of the outside and inside rays, an object of half this angular diameter may be shown to have real dimensions, but below this value the telescope cannot distinguish between a real and spurious diameter.

63–64 Remarks on the class of celestial bodies to which the new star belongs, and a justification of the term ASTEROID as applied to them.

[Dated] Slough, near Windsor, December 1, 1804.

1805 95 233 *On the direction and velocity of the Motion of the Sun, and Solar System.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read May 16, 1805.

233 Dr. MASKELYNE'S Table of the proper motions of 36 stars proves the motions of the stars of the first brightness, such as are probably in our immediate neighborhood. The changes in position of minute stars that I have ascertained prove that motions are equally carried on in the remotest parts of space.

233 In 1783 I deduced from the proper motions of stars, with a high degree of probability, a motion of the sun and solar system towards λ *Herculis.*

234 The present paper will treat [only] of the *direction* of the solar motion.

234 *Reasons for admitting a solar motion.*

It may appear singular that I should again think it necessary to give reasons for this. The cause is that [in 1783 I proposed to] take away the various proper motions of stars by investing the sun with a contrary one. Now, however, [I find that] the solar motion will reveal so many concealed real motions that we shall have more of them than would be necessary were the sun at rest. Hence the necessity for admitting the solar motion ought to be well established.

235 *Theoretical considerations.*

235 A view of the motions of moons around planets, and these again round the sun, may suggest the motion of the latter round some unknown centre. The solar motion was suggested by LAMBERT; Dr. WILSON has shown its possibility from theoretical principles, and DE LA LANDE its probability. The rotation of the sun indicates a motion of translation; the cause of both is unknown.

236 The periodical stars should be examined with this idea. Conversely stars that have a motion in space may be surmised to have also a rotation on their axes.

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1805 95 236 *Symptoms of parallactic Motions.*
Three sorts of motions explained by Fig. 1, Plate VII.
237 The parallactic, the real, and the apparent motions.
238 Since a motion of the sun will occasion parallactic motions of the stars, these again must indicate a solar motion. To ascertain whether parallactic motions exist we must choose the brightest stars which are most affected by solar motion, they being probably the nearest to the sun.
238 We distinguish parallactic from real motions by the direction of the motion. If a solar motion exists all parallactic motions will be opposite to it; real motions will be dispersed indiscriminately to all parts of space.
239 The point towards which the sun moves is the apex of solar motion; the opposite point is the parallactic centre.
240 Table I. Ten positions of the solar apex from first magnitude stars.
241 Fifteen positions from fainter stars stated.
242 *Changes in the position of double Stars.* Among the 56 stars which I have given, the changes of more than half appear to be [due to a solar motion].
242 *Incongruity of proper Motions.*
242 *Sidereal occultation of a small Star.*
As far as we can judge at present the vanishing of the small star near *δ Cygni* is only a parallactic disappearance. A real motion would also explain it.
244 *Direction of the Solar Motion.*
248 When we are in search of an apex for the solar motion, it ought to be so fixed as to be equally favorable to every star. * * * Our aim should be to reduce the proper motions of the stars to their lowest quantities.
249 Table II of the direction and quantity of the apparent motion of six stars, supposing the sun to move towards *λ Herculis.*
251 Table III of the angles of the parallactic motion with the parallel; and Table IV, angles of the apparent with the parallactic motion.
252 Table V. Quantities and sum of the least real Motions.
253 Assuming the apex of solar motion to be in R. A. 270° 15′, N. P. D. 54° 45′, Table VI is computed: it is similar to Tables III, IV, V.
254 Assuming the apex R. A. 245° 52′ 30″, N. P. D. 40° 22′, Table VII [like Table VI] is calculated.
255 Although the great proper motions of *Arcturus*, *Procyon*, and *Sirius* are strong indications of their being affected by parallax, it is not probable that their apparent changes are entirely due to solar motion.
256 Observation shows that proper motions do exist: we should choose that apex which will take away more real motion than any other, or we should put the apex in R. A. 245° 52′ 30″, N. P. D. 40° 22′.

1805 95 272 *Observations on the singular Figure of the planet Saturn.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read June 20, 1805.
272 [Brief account of the particularities of the system of *Saturn.*]
272 There is a singularity left which distinguishes the figure of *Saturn* from that of all the other planets. In 1776 I perceived that the
273 body of *Saturn* was not round. In 1781 I found it was flattened at the poles more than *Jupiter*. In 1789 I measured the polar and equatorial diameters, and prepossessed with the idea of its being spheroidical I [paid no attention to other diameters].

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1805	95	273	Observations on *Saturn:* [from 1805, April 12, to June 2] 1805, April 12. The ring is brighter than the body, and whiter.
		274	April 18. The figure of *Saturn* is different from the spheroidical figure of *Jupiter.* The 4 points of greatest curvature are in latitude 46° 38′.
		275	The shadow of the ring on the body is broader at the ends than in the middle.
		275	April 19. The figure of *Saturn* is like a parallelogram with the four corners rounded off deeply. The latitude of the four points of greatest curvature is 45° 44′.5.
		276–277	May 5–13. *Saturn* and *Jupiter* were viewed alternately [and the preceding remarks confirmed].
		279	The real *Saturn* compared with the figure in *Phil. Trans.*, 1790, p. 17. The two did not agree. I then modified the latter and made them agree. An exact copy is given in Plate IX.
		280	Dimensions of the parts given.
1806	96	205	*On the Quantity and Velocity of the Solar Motion.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read February 27, 1806.
		205	The direction of the solar motion was ascertained in a former paper: the velocity is now in question.
		205	The proper motions, reduced to one direction, have been called quantities, to distinguish them from the velocities of the moving stars, required to produce those motions. The same distinction must be kept with respect to the velocity of the solar motion.
		205	At a given distance, when the quantity of the solar motion is known, its velocity is known, and every approximation towards a knowledge of the distance of a star of the first magnitude will be one toward a knowledge of the real solar velocity. It is otherwise with a star, for the angle of the direction of its motion with the visual ray is unknown.
		206	I shall use the former six stars in the present paper.
		206	*Proportional distance of the Stars.*
		207	I propose the following arrangement: Table VIII, *proportional Distances of Stars; Sirius,* 1.00; *Arcturus,* 1.20; *Capella,* 1.25; *Lyra,* 1.30; *Aldebaran* and *Procyon,* 1.40.
		208	I have tried all the known and many new ways of measuring the comparative light of the stars, and no one gives a satisfactory result. When we have more authentic data, the calculation may be repeated.
		208	*Effect of the increase and decrease of the Solar Motion and Conditions to be observed in the Investigation of its Quantity.*
		209	Table IX. In 6 columns: Stars; Apparent motion; Solar motion; Parallactic motion; Real motion; Velocities.
		210	It is not the motions but the velocities which must be equalized.
		211	It is assumed that their real motions are at right angles to the visual ray. [The objection to this considered.]
		213	*Calculations for drawing Figures that will represent the observed motions of the Stars.*
			These are of two classes; the first will remain unaltered whatsoever the solar motion; the second must be adjusted to every change [of solar motion].
		214	We must assume relative distances for the rest of our stars.

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1806 96 215 Table X contains the result of calculation of the permanent quantities. It has six columns: (1) gives the star's name; (2) its proportional distance; (3) apparent motion; (4) Direction with the parallel; (5) Direction with the parallactic motion; (6) Velocity. [There are 36 stars.]

216 Plate IV, Fig. 1 and Fig. 3, exhibits columns 3, 4, and 5 graphically. Fig. 2 and Fig. 4 give the velocities.

217 *Remarks on the sidereal Motions as they are represented from Observation.*

Fig. 1 (from observation) shows that there must be some physical cause which gives a bias to the directions in which the stars are moving. Discussion of Figs. 2, 3, 4.

219 *The Solar Motion and its direction assigned in the first part of this paper are confirmed by the Phenomena attending the observed motions of* 36 *stars.*

221 *Trial of the method to obtain the Quantity of the Solar Motion by its Rank among the sidereal Velocities.*

222 *Calculations for investigating the Consequences arising from any proposed Quantity of Solar Motion and for delineating them by proper Figures.*

223 Table XI contains 5 columns: (1) name of star, including the sun; (2) Parallactic Motion; (3) Real Motion; (4) Parallactic Angle; (5) Velocity.

224 Figs. 5 and 6 illustrate Table XI.

224 *Remarks that lead to a necessary examination of the Cause of the sidereal Motions.*

225 A motion of the stars may arise from mutual gravitation or from an original projectile force. Both these causes act in the solar system.

225 The similar direction of the motion of a group of stars may be ascribed to their similar projectile motions.

227 *Considerations of the attractive Power required for a sufficient Velocity of the sidereal Motions.*

The mere attraction of neighboring stars acting upon each other cannot be the cause of proper motions. *Sirius* and the Sun from that cause would approach yearly by less than 0″.000000005 to an eye at the distance of *Sirius* and supposing its parallax 1″.

228 A centre of attraction must then be assumed, and original projectile
229 motions must be supposed.

229 The centre of attraction may be one mass or a group.

230 Or it may be a union of groups; like two clusters 12° apart which are near the line of the solar motion.

231 The Milky Way will furnish centres of attraction.

231 Independent of the solar motion, the action of distant centres of attraction will be required to explain the proper motions of stars. If the Sun be at rest *Arcturus* moves 2″ a year; and this must be due to a projectile motion and the attraction of far distant centers.

232 *Determination of the Quantity of the Solar Motion.* The rank assigned to the solar motion is a perfect medium among the [36] sidereal velocities [which have been considered.]

233 The quantity of the solar motion is such that to an eye placed at right angles to its direction, and at the distance from *Sirius*, it would be annually 1″.116992.

234 *Concluding Remarks and Inferences.* [Objections considered.]

234 When a general knowledge of the proper motions of all the stars of the 1st, 2d, and 3d magnitudes has been obtained, the present calculation can be repeated by the same methods.

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1806 96 235 The result of calculations founded on facts, such as we must admit the proper motions of the stars to be, should give us useful information, to satisfy the inquisitive mind or to lead us on to new discoveries. The establishment of the solar motion answers both these ends. Our inquiries should not terminate here. A paper on general Gravitation [by Dr. WILSON] with what is said here, puts us within reach of a link of the chain which connects the principles of the solar and sidereal motions with those which are the cause of so many orbitual ones.

236 What has been said before of the Sun as an insulated star does not contradict the present idea of its making one of a very extensive system.

237 The insulation refers merely to a supposed binary combination with some neighboring star.

1806 96 455 *Observations and Remarks on the Figure, the Climate, and the Atmosphere of Saturn and its Ring.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read June 26, 1806.

455–457 [Account of HERSCHEL's observations on the figure of the ball.] Plate XXI, Fig. 1, represents *Saturn* in 1789, and Fig. 2, in 1805, May 5.

458 To discover the flattening of the figure of the ball a high magnifying power (500) was necessary. A lower power will afterwards show it. No error could arise from the defalcation of light May 5, 1805.

459–464 *Observations of the figure of Saturn.*

462 The flattening at the poles of *Saturn* is more extensive than on *Jupiter*. The curvature in high latitudes is also greater. At the equator it is rather less. Upon the whole the shape of the globe of *Saturn* is not such as a rotatory motion alone could have given it.

462 1806, June 3. The shadow of the ring on the ball is broader at the ends than in the middle.

463 The breadth of the ring is to the space between the ring and the ball as about 5 to 4. The ring appears to be sloping towards the ball.

463 The shadow of the ball on the ring is not parallel with the outline of *Saturn*.

464 *Observations on the periodical changes of color of the polar regions of Saturn.* In the observations of *Mars* (*Phil. Trans.*, 1784, p. 260) it has been shown that a periodical change takes place in the extent and brightness of the polar spots. I have suggested that this may be due [to frozen regions at the poles, varying in size as they are more or less exposed to the Sun.]

The following observations may lead to similar conclusions with respect to *Saturn*.

466 The gradual change of color of the polar region during a Saturnian year seems to be in a great measure ascertained. This can only be confirmed by a long series of observations.

466 *On the atmosphere of Saturn.*

From observations we may infer the existence of a Saturnian atmosphere.

467 A probability that the ring of Saturn has an atmosphere has been pointed out in a former paper.

[Dated] Slough near Windsor, June 12, 1806.

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1807 97 180 *Experiments for investigating the Cause of the coloured concentric Rings, discovered by* Sir ISAAC NEWTON, *between two Object-glasses laid upon one another.* By WILLIAM HERSCHEL, LL D., F. R. S. Read February 5, 1807.

180–181 Introduction.

182–185 I. *Of different methods to make one set of concentric rings visible.*

185–186 II. *Of seeing Rings by Transmission.*

187–188 III. *Of Shadows.* When two or more sets of rings are to be examined they may be distinguished by casting the shadow of a pointed penknife upon one set or another.

188–193 IV. *Of two sets of Rings.*

193–194 V. *Of three sets of Rings.*

195 VI. *Of four sets of Rings.*

195–196 VII. *Of the Size of the Rings.*

196 VIII. *Of Contact.*

197 IX. *Of Measuring Rings.*

197–198 X. *Of the Number of Rings.*

198–199 XI. *Of the Effect of Pressure on the Colour of the Rings.*

199–200 XII. *Of diluting and concentrating the Colours.* When the rings grow wider by using a lens of larger radius, they are said to be diluted.

201 XIII. *Of the order of the Colours.*

201–202 XIV. *Of the alternate Colour and Size of the Rings belonging to the primary and dependent Sets.* Certain of the dependent sets are rings by transmission as seen reflected at the back surface of the lower plate.

202–203 XV. *Of the sudden Change of the Size and Colour of the Rings in different Sets.* This is brought about by letting the shadow of the knife-blade fall on one or the other set.

204–206 XVI. *Of the course of the Rays by which different Sets of Rings are seen.*

206–207 XVII. *Why two connected Sets of Rings are of alternate Colours.*

207–208 XVIII. *Of the Cause of the sudden Change of the Colours.*

208–209 XIX. *Of the Place where the different Sets of Rings are to be seen.*

209–210 XX. *Of the Connection between different Sets of Rings.*

211–212 XXI. *To account for the Appearance of several Sets of Rings with the same coloured Centers.*

212–213 XXII. *Of the reflecting Surfaces.*

213–214 XXIII. *Of the transmitting Surfaces.*

214–218 XXIV. *Of the Action of the first Surface.*

218–221 XXV. *Of the Action of the second Surface.*

221–222 XXVI. *Of the Action of the third Surface.*

222 XXVII. *The Colour of the reflecting and transmitting Surfaces is of no consequence.*

222–225 XXVIII. *Of the Action of the fourth Surface.*

225 XXIX. *Considerations that relate to the Cause of the formation of concentric Rings.*

226 XXX. *Concentric Rings cannot be formed by an alternate Reflection and Transmission of the Rays of Light.*

"One of the most simple methods of obtaining a set of concentric rings is to lay a convex lens on a plain metalline mirror; but in this case we can have no transmission of rays, and therefore we cannot

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have an alternate reflection and transmission of them. If to get over this objection it should be said that, instead of transmission, we ought to substitute absorption; since those which in glass would have been transmitted will be absorbed by the metal, we may admit the elusion; it ought, however, to have been made a part of the hypothesis."

1807 97 226-228 XXXI. *Alternate Fits of easy Reflection and easy Transmission, if they exist, do not exert themselves according to various Thicknesses of thin Plates of Air.* One end of a plain strip of glass rested upon a plain metalline mirror, the other end being separated from the mirror by a thin piece of paper. A lens resting upon the strip of glass gave the primary set of rings, and the secondary set by transmission was seen reflected in the metalline mirror. The rays which convey the secondary set of rings to the eye must have passed through the thin wedge of air; but they exhibited no modification, hence the conclusion.

228-229 XXXII. *Alternate Fits of easy Reflection and easy Transmission, if they exist, do not exert themselves according to various Thicknesses of thin Plates of Glass.* An experiment similar to the preceding, but using a slip of glass with sides not quite parallel.

230-232 XXXIII. *Coloured Rings may be completely formed without the Assistance of any thin or thick Plates, either of Glass or of Air.* A perforated screen, at the center of curvature of a metal mirror, transmitted a beam of sunlight to the mirror. When hair-powder was strewn in the beam of light, coloured concentric circles were seen about the hole in the screen.

232-233 XXXIV. *Conclusion.* The experiments of the last three articles are regarded as proofs that the theory of Sir ISAAC NEWTON is untenable.

1807 97 260 *Observations on the Nature of the new celestial Body discovered by* Dr. OLBERS, *and of the Comet which was expected to appear last January in its return from the sun.* [This was comet, 1806, II.] By WILLIAM HERSCHEL, LL. D., F. R. S. Read June 4, 1807.

260 As soon as I knew of the discovery of [*Vesta*] I tried to discover its situation.

262 Observations of *Vesta*.

263 No disc has been seen even with a power of 636.

264 *Observations of the expected comet.* It was searched for and found near the expected place by my Sister CAROLINA, Jan. 27.

266 Out of 16 comets which I have examined 14 have been without any visible solid body in their centre, and two had a very ill-defined small central light which might perhaps be called a nucleus, but which did not deserve the name of a disk.

266 Plate XVI. Configurations of *Vesta* and stars.

1808 98 145 *Observations of a Comet made with a view to investigate its Magnitude and the Nature of its Illumination.* [This was comet, 1807, I.] *To which is added an Account of a new Irregularity lately perceived in the apparent Figure of the Planet Saturn.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read April 7, 1808.

145 My observations have been directed to its physical condition only.

146 *Of the Nucleus.* By the nucleus, I mean that part of the head which appears to be a condensed or solid body, and in which none of the very bright coma is included. It follows from this definition that when the nucleus is very small a large telescope is required to show it.

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1808 98 147 *Observations.* (By the method described in *Phil. Trans.*, 1805, p. 53.) The visible disk of the comet is a real one.

147 *Illumination of the Nucleus.* The nucleus is round and of equal brightness all over its disk. Its color is a little tinged with red.

148 *Magnitude of the Nucleus.* It appears larger at first sight than after looking a long while.

148 I put a number of globules of sealing wax at a known distance and viewed them during the day, and remembered their [apparent] magnitudes. The nucleus was compared with these and must have been larger than 2″.47 and less than 2″.77. It was less than the disk of *Jupiter's* satellite III.

150 *Of the head of the Comet.* [Definition of the head.]

151 *Of the Coma of the Comet.* [Definition of the coma.]

151 *Of the tail of the Comet.*
One side of the tail is very well defined; the other, hazy.

152 *Of the Density of the Coma and Tail of the Comet.*
I took notice of many small stars covered by the Coma and tail. [The observations show that the interposition of the coma or tail between a faint star and the eye, dimmed the star.]

153 *Nebulous appearance of the Comet.*

154 *Result of the foregoing Observations:*

156 The real diameter of the nucleus was 538 miles.

156 I computed the phases of the comet (see Fig. 1 and Fig. 2, Plate IV, p. 162) for two dates. Both phases appear to me sufficiently defalcated to prove that the comet did not shine by reflected sun-light only.

157 If these remarks are well founded, we are authorized to conclude that the body of the comet on its surface is self-luminous. Its light is more like starlight than moonlight.

157 The tail and coma are sufficiently dense to obstruct the free passage of starlight; they shine, not by reflection but by their own radiance.

159 If I had met the comet in one of my sweeps as it appeared between Dec. 6 and Feb. 21 I should have put it down as a nebula. Perhaps my lists of nebulæ, then, contain some comets.

159 *Account of a new irregularity lately perceived in the apparent Figure of the planet Saturn.*

160 I have ascribed the flattening of the polar regions to the attraction of the ring. In pursuing my observations I perceived a new irregularity in the figure [of the ball] which I am perfectly sure had no existence the last time I examined the planet.

160 *Observations* [of the flattening in high latitudes] 1807, June 16, I perceived it; it was independently drawn by my son, JOHN HERSCHEL.

161 Dr. WILSON, late of Glasgow, sent me a drawing containing the same features made with one of my 7-foot reflectors at Hampstead.

162 Explanation of the "illusion" by refraction of the light from the body of *Saturn* in the atmosphere of the ring.

163 The ring has an atmosphere (see *Phil. Trans.*, 1790, p. 7).

1809 99 259 *Continuation of Experiments for investigating the Cause of coloured concentric Rings, and other Appearances of a similar Nature.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read March 23, 1809.

259–260 XXXV. *Cylindrical Curves produce Streaks.*

261 XXXVI. *Cylindrical and spherical Surfaces combined produce coloured elliptical Rings.*

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1809 99 261–262 XXXVII. *Irregular Curves produce irregular Figures.*

XXXVIII. *Curved Surfaces are required for producing the coloured Appearances at present under consideration.*

263 XXXIX. *Coloured Appearances cannot be produced between the plain Surfaces of two parallel Pieces of Glass applied to one another.*

This conclusion is derived from the observation that colours appear between two such glasses only when they are pressed together with considerable force; but such pressure necessarily produces distortion of form in the glasses.

264–265 XL. *Of the Production of coloured Appearances.*

265 The colours contained in white light may be separated by reflection, as well as by refraction. The production of the blue bow at the limit of total reflection, as described by Sir ISAAC NEWTON, is an instance of this effect.

266–268 XLI. *Particulars relating to the Newtonian prismatic blue Bow.*

A description of the phenomenon, with a calculation of its place and breadth in a particular case.

268–272 XLII. *Account of a prismatic red Bow.*

268 This consists of red, orange, yellow, and some green rays, the red colour being very predominant. To see the red bow, an observer should place himself in the open air, and, standing with his back within a few feet of some wall or building, hold the sides of an equilateral prism flat over his eyes, and look upwards to an altitude of about 30° at the heavens.

269 Calculations relating to this bow.

270–271 Method of projecting the bow.

272–274 XLIII. *Of a sudden Change of the Colours of the Bows.*

272 If a right-angled prism be laid down on a sheet of white paper before a window, and the eye be placed in the proper position for seeing the blue bow, we may instantly transform it into red one by covering the side of the prism which is toward the incident light with a slip of pasteboard.

273 Relative positions of red and blue bows.

274–276 XLIV. *Of Streaks and other Phenomena produced from the prismatic blue and red Bows.*

These may be produced by applying a surface of glass or metal to that surface of the prism which produces the one or the other bow.

276–279 XLV. *Explanation of various Appearances relating to prismatic Bows.*

280–281 XLVI. *The first Surface of a Prism is not concerned in the Formation of the blue Bow, nor of the Streaks that are produced by a plain Glass applied to the efficient Surface.*

281–284 XLVII. *The Streaks which may be seen in the blue Bow contain the colours of both the Parts of the prismatic Spectrum, by the critical separation of which the Bow is formed.*

282 List of colours observed in streaks.

284–291 XLVIII. *On the Formation of Streaks.*

This is an effort to determine by calculation some of the features of the phenomenon under the supposition that the streaks are produced by a reflection, at the surface of the glass plate, of the light transmitted by the prism near the critical angle.

291–292 XLIX. *Prismatic Bows, when seen at a Distance, are straight Lines.*

292–294 L. *The colours of the Bow-streaks owe their Production to the Principle of the critical Separation of the different Parts of the prismatic Spectrum.*

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1809 99 294–298 LI. *A Lens may be looked upon as a Prism bent round in a circular Form.*

299–302 LII. *The critical separation of the Colours, which takes place at certain Angles of Incidence, is the primary cause of the Newtonian coloured Rings between Object-glasses.*

300–301 A comparison of the similarities presented by the phenomena of the rings and those of the bows, modified by a reflecting plate in contact with the effective surface of the prism.

302 LIII. *Remarks relating to the Newtonian alternate Fits of easy Reflection and easy Transmission.*

[Dated] Slough, near Windsor, December 9, 1808.

Plates XII, XIII, XIV.

1810 100 149 *Supplement to the First and Second Part of the Paper of Experiments for Investigating the Cause of Coloured Concentric Rings between Object-glasses, and other appearances of a similar nature.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read March 15, 1810.

149–150 A statement of the object of this supplement, and a discussion of the distinctions between the red and blue bows.

151–153 LIV. *Supplemental Considerations, which prove that there are two primary prismatic Bows, a blue one and a red one.*

154–157 LV. *Illustration of the Dependence of the Streaks of both Bows upon the critical Separation.*

157–159 LVI. *Illustration of the dependence of Rings, seen in a Prism, upon the critical Separation.*

159–161 LVII. *Remarks on Colours supposed to be produced by thin Plates or Wedges of Air.*

A repetition of the experiment of the 39th Article slightly modified. Two slips of plain glass touching at one end were separated at the other by a single fibre of silk. It is concluded that the phenomenon of coloured streaks seen near the line of contact is so well accounted for by the 35th Article that it would not be philosophical to ascribe them to plain surfaces.

161–163 LVIII. *Illustrating Remarks on the Intention of the* 14*th Figure, explained in the* 48*th Article of my Paper.*

164–166 LIX. *Experiments on the multiplying Power of Surfaces, in contact, which modify the form of prismatic Appearances.*

166–168 LX. *Of the breadth of the Streaks compared to that of the Bows, and the cause why they must take up a broader space than the Bows from which they are derived.*

169–177 LXI. *Of the Manner in which Rays that are Separated by critical reflection or Intromission come to the Eye.*

Plates V, VI.

1811 101 269 *Astronomical Observations relating to the Construction of the Heavens, arranged for the purpose of a critical examination, the result of which appears to throw some new light on the Organization of the Celestial bodies.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read June 20, 1811.

332 "*Synopsis of the Contents of this Paper.*"

[The following analysis is by HERSCHEL himself and has served as a model to us.]

272 Diffused nebulosity exists in great abundance.

275 Observations of more than one hundred and fifty square degrees of it.

277 Its abundance exceeds all imagination.

Nebulous matter consists of substances that give out light, which may have many other properties.

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1811 101 278–281 Nebulous diffusions contain both milky nebulosity, and such as from its faint appearance may be mistaken for resolvable.

278–279 The range of its visibility is confined to very moderate limits.

280 The purpose for which such great abundance of nebulosity may exist deserves investigation.

282 Either greater depth or greater compression of the nebulous matter may occasion greater brightness.

284 Condensation will best account for greater brightness.

The condensation of the nebulous matter ascribed to gravitation.

285 When a nebula has more than one preponderating seat of attracting matter, it will probably in time be divided.

This conception is supported by the appearance of double nebulæ.

286 Their double appearance can be no deception.

Their nebulosity is derived from one common stock.

290 This opinion is supported by the remarkable situation of nebulæ.

292 Which may be seen in Mr. BODE's *Atlas Cœlestis.*

293–296 The real form of the nebulous matter of which nebulæ are composed may be inferred from their figure.

299 The form of the nebulous matter of round nebulæ is globular.

This form is caused by gravitation.

302 The central brightness of nebulæ points out the seat of attraction.

The effect of attraction on the form of the nebulous matter depends on its original expansion, on the time of the action, and on the quantity of the attracting matter.

305 III different stages of condensation pointed out.

306 Comets may be highly condensed nebulæ.

307 Progressive condensation takes place.

308 Concentric brightness as well as globular form indicates the general gravitation of the nebulous matter.

Progressive condensation may be seen in the formation of nuclei.

309–310 Nebulous matter is probably capable of being consolidated; the act of shining proves it to have chemical properties.

It will stop light, and is partly opaque.

311 Queries relating to the subsidence of the nebulous matter, the zodiacal light, and the cause of rotatory motion.

313 Some part of the nebulous matter is probably elastic.

313 The uniform light of nuclei, and of much condensed nebulæ, proves that the nebulous matter is considerably opaque.

314 When the nebulous matter assumes hardness, the progress of condensation will be impeded.

315 Three indications of the compression of the nebulous matter.

Planetary appearance arises from superficial lustre.

316 High degree of condensation of the nebulous matter.

A still higher degree of condensation.

318 In common good telescopes planetary nebulæ cannot be distinguished from stars.

Perhaps they may in the end be so condensed as actually to become stars.

319 The nebulous matter in a cubical space of 10′ will admit of a condensation of two trillion and 208 thousand billion times before it can go into the compass of a globe of the diameter of our sun.

Planetary nebulæ have a rotatory motion on their axes.

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The original eccentricity of the nebulous matter of a nebula may be the physical cause of the rotatory motion of celestial bodies.

1811 101 320 The nebulous star in *Orion* is fictitious.

321 Two out of three nebulous stars in *Orion* have lost their former nebulous appearance.

Their fictitious appearance was owing to a dispersion of their light in passing through nebulous matter.

322 The faintest appearance of the nebulosity in *Orion* is perhaps not further from us than the stars of the third or second magnitude; the brightest part is therefore probably not so far.

323 In thirty-seven years the nebulosity of this nebula has undergone great changes, and much greater since the time of HUYGHENS.

324 Nebulæ are not permanent celestial bodies.

325 Additional proof of the opacity of the nebulous matter.

325 Very distant nebulosities which cannot be seen in a state of diffusion may become visible when condensed into separate nebulæ.

327 Conversion of planetary into bright stellar nebulæ, into stars with burs, or stars with haziness.

329 Conversion of more distant ones into faint stellar nebulæ, into stars with burs or with faint chevelure.

When it is doubtful whether an object is a star or a nebula, it may be verified by an increase of magnifying power.

330 When the object is very like a star it becomes difficult to ascertain whether it is a star or a nebula.

When we cannot ascertain whether the doubtful object is a star or a nebula, of which several instances are given, the similitude is as great as any we can expect; for were it greater there could be no doubt.

336 Postscript.

[Dated] Slough, near Windsor, May 26, 1811.

WILLIAM HERSCHEL.

336 Plates IV & V; 42 figures of nebulæ.

1812 102 115 *Observations of a Comet, with remarks on the Construction of its Different Parts.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read December 19, 1811. [This was Comet 1811, I.]

115 I have examined all the parts of the late comet with a scrutinizing attention by telescopes of every degree of requisite light, distinctness, and power. I have made so many observations that I shall only give a selection of such as were made under the most favorable circumstances.

115 *The Planetary Body in the Head of the Comet.*

Where with the naked eye I saw a luminous appearance not unlike a star, with a telescope I found that this spot, which some might call a nucleus, was only the head of the comet.

116 Within its densest part was an extremely small bright point entirely distinct from the surrounding glare. Its contour was certainly not otherwise than round, yet I could but very seldom perceive it definedly to be so.

116 I examined this point with various magnifiers on a 10-feet telescope. With 169 it was about 1″.39 in diameter.

117 With 600 it was between 1″.06 and 0″.68. The sealing-wax globules were viewed the morning after the observation as well as the morning before. [See *Phil. Trans.*, 1808, p. 145.]

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1812 102 118 *The apparent and real Magnitude of the Planetary Body.* I call its apparent diameter 0″.775; that is, its real diameter was about 428 miles.

118 *The Eccentricity and Color of the planetary Body.*

The planetary body was eccentric in the head.

119 The color was of a pale ruddy tint like that of such equally small stars as are inclined to red.

119 *The Illumination of the Planetary Body.*

We may infer [from observations] that it was visible by rays emitted from its own body.

119 *The Head of the Comet.*

120 [Description of the head.]

120 *The Color and Eccentricity of the Head.*

The color in every one of my telescopes was greenish or bluish green.

121 The head was eccentric; it deviated towards the sun.

121 *The Apparent and Real Magnitudes of the Head.*

The real diameter of the head was about 127,000 miles.

122 *A Transparent and Elastic Atmosphere about the Head.*

I saw stars through it; it was thus transparent. Its elasticity may be inferred from its circular form.

122 *The extent of the Cometic Atmosphere.*

It was more than 507,000 miles in diameter; its real extent far exceeds this.

122 *The Bright Envelope of the Cometic Atmosphere.*

123 *The Figure, Color, and Magnitude of the Atmosphere.*

Its shape was circular; it reached nearly half way round the head of the comet, and divided into two streams, one on each side of the head. The color had a strong yellowish cast. Its real diameter must have exceeded 643,000 miles.

123 *The Tail of the Comet.* It was, Oct. 15, 23½° long.

124 *The greatest real length of the Tail.*

It must have been upwards of 100,000,000 miles.

124 *The Breadth of the Tail.* It was, Oct. 12, nearly 15,000,000 miles.

125 *The Curvature of the Tail.*

This was subject to variations.

125 *The general appearance of the Tail.*

126 The tail had two branches. [See observations.] November 9 the tail of the comet being near the Milky Way, the appearance of one compared to the other was perfectly alike.

127 *The return of the Comet to the Nebulous Appearance.*

As the comet went further from the earth I had reason to suppose that all the still visible phenomena of body, head, atmosphere, envelope, and tail would soon be reduced to the semblance of a common globular nebula. And this, not only from its increasing distance but by the actual physical changes which I observed in the construction of the comet.

127 *The gradual vanishing of the Planetary Body.*

128 *The disappearance of the transparent part of the Atmosphere under the cover of the scattered light of the contracted Envelope.*

129 *Uncommon Appearances in the Dissolution of the Envelope.*

One, two, and three streams seen in it at different times.

130 *Uncommon Variations in the Length of the Streams.*

131 *Alterations in the Angle of the Direction of the Envelope.*

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1812	102	131	*The shortening of the Tail.*
		132	*Increasing Darkness between the Streams that enclose the Tail.*
		133	*Of the real construction of the Comet, and its various Parts.*
		133	The form of the planetary body containing the solid matter of the comet is globular.
		133	The transparent cometic atmosphere is also globular.
		134	The envelope must have been an inverted hollow cone terminating at its vertex in an equally hollow cap nearly hemispherical.
		134	This hemispherical cap was comparatively thin.
		135	The construction of the envelope explained.
		136	The luminous matter as it arises from the envelope, of which it is a continuation, is thrown a little outwards and assumes the appearance of two diverging bright streams; but if the source from which they rise be the circular rim of a hollow hemispherical shell the luminous matter in its progress upwards can only form a hollow cone.
		136	The feebler light of the tail between the streams is due to the thinness of the matter in the middle of the hollow cone through which we look.
		136	*Of the Solar agency in the production of Cometic Phenomena.*
		137	As a comet approaches perihelion it is [more] exposed to the action of the solar rays, which can produce light, heat, and chemical effects. Their influence on this comet has produced an expansion. The way these effects have been produced may be supposed to have been as follows:
		137	The matter in the head of the comet would be dilated by the action of the sun, chiefly in that hemisphere of the head nearest the sun; and, being more increased in this direction than the other, it would become eccentric when referred to the situation of the body of the comet. The head being what draws our greatest attention, the planetary body would appear eccentrically situated.
		137	The nebulous matter which, when the comet is far from perihelion, is probably spherical, would, near perihelion, be rarefied and rise to a certain level. In this situation we have had an opportunity of seeing the transparent atmosphere, which, but for the suspension of the nebulous matter, we might never have discovered.
		138	The brilliancy and color of the envelope are proofs of the continued action of the sun, and if we suppose the attenuation of the luminous matter, already very rare, to be carried on, its particles will gradually recede from the hemisphere exposed to the sun and ascend towards the region of the fixed stars. Some such operation must have been carried on.
		138	A whole hemisphere of it being exposed to the sun, it must ascend equally everywhere all round this and become a hollow cone.
		139	The luminous matter ascending in the hollow cone received no addition to its quantity from any other source but the exposed hemisphere.
		139	The tail, near the end, must have been rarefied in an extreme degree.
		139	The vacancy occasioned by the escape of the nebulous matter was probably filled up, either from the opposite hemisphere or by a rotation of the comet about an axis.
		139	That such a process took place seems to be supported by observation.
		140	A rotatory motion of the comet would explain the variation in the lengths of the two branches of the tail.

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1812 102 140 *Of the result of a Comet's Perihelion Passage.*

The quality of giving out light is immensely increased by an approach to the sun.

141 The act of shining denotes a decomposition in which at least light (and perhaps many other elastic volatile substances) is given out. I look upon a perihelion passage in some degree as an act of consolidation.

141 If this idea be admitted, may we not conclude that the consolidation of the comet of 1807, when at perihelion, had already been carried to a much higher degree than that of the present one, by some former approach to our sun, or to other similar celestial bodies, such as we have reason to believe the fixed stars to be?

142 It is probable that comets may pass around other suns than ours.

142 Have we not reason to suppose that the comet of 1807 was comparatively a much older comet?

142 Should the idea of age be rejected, we may suppose that the comet of 1811 since the time of some former perihelion passage may have acquired a quantity of "*unperihelioned* matter" by passing through extensive strata of nebulosity.

142 I think it not unlikely that the matter of comets is originally nebulous. It may possibly happen that highly condensed nebulæ may be drawn towards the nearest celestial body of the nature of our sun, and, after their first perihelion passage round it, proceed towards some other similar body, and finally may come into the regions of our sun, where at last we perceive them as comets.

143 The brilliant appearance of our comet may be ascribed either to its having but lately emerged from a nebulous condition, or to its having carried off some [foreign] nebulous matter. The first case will lead us to conceive how planetary bodies may begin to have an existence; the second how they may increase and grow up to maturity.

WM. HERSCHEL.

[Dated] Slough, near Windsor, December 16, 1811.

1812 102 229 *Observations of a second Comet, with Remarks on its Construction.* [Comet 1811, II.] By WILLIAM HERSCHEL, LL. D., F. R. S. Read March 12, 1812.

229 I call this the *second* comet; the other of this year the *first*.

The Body of the Comet.

231 The nucleus was 5″.2744 in diameter.

232 The real diameter of its nucleus cannot be less than 2,637 miles.

232 *The chevelure of the Comet.*

233 *The Tail of the Comet.* Its length on January 20 must have been about 659,000 miles.

233 *Remarks on the Construction of the Comet.*

234 When the two comets are compared they are found to be extremely different.

234 The light of the second comet is probably reflected from the sun. The nucleus of the comet is surrounded by an elastic atmosphere, which is transparent.

235 The little extent and extreme faintness of the tail might be ascribed to the great perihelion distance of the comet if the comparative view of the comets of 1807 and 1811 in my last paper did not prove

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that the effect of the solar agency depends entirely upon the state of the nebulous matter of which the comet is composed. This second comet had probably but little *unperihelioned* matter.

1812 102 236 If, then, the effect of the sun on comets is more or less conspicuous, according to the amount of unperihelioned nebulous matter which they contain, we may arrange these celestial bodies in a certain order of consolidation, from which, in the end, a considerable insight into their nature and destination may be obtained.

236 For example, the comet of this paper is of such a construction that it was but little more affected by its perihelion passage than a planet would have been. It was in a very advanced state of consolidation.

237 That of 1807 was more affected, and, although considerably condensed, conveyed a great quantity of nebulous matter to the perihelion passage. That of 1811 contained, with little solidity, a most abundant portion of nebulous matter.

1814 104 248 *Astronomical Observations relating to the Sidereal part of the Heavens and its Connection with the Nebulous part; arranged for the purpose of a critical examination.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read February 24, 1814.

In the memoir on the nebulous part of the heavens [*Phil. Trans.*, 1811] I have endeavored to show the probability of a very gradual conversion of the nebulous matter into the sidereal appearance. This paper refers to the sidereal part of the heavens.

249 I. *Of stars in remarkable situations in regard to Nebulæ.*

Surmise that nebulæ may have considerable proper motions. Necessity of caution in such conclusions. Five stars in such situations.

250 II. *Of two stars with nebulosity between them.*

19 instances of such connection are given; in the memoir of 1811, 139 double nebulæ joined by nebulosity were noted.

251 Should we not surmise that possibly these stars had formerly been highly condensed nebulæ like those that had been mentioned, and were now by gradually increasing condensation turned into small stars; and may not the nebulosity still remaining show their nebulous origin? Also as we have over 700 double stars free from nebulosity, many of which are probably at no great real distance from us, it seems as if we might have these double objects in three different successive conditions. First, as nebulæ; next as stars with remaining nebulosity; and lastly, as stars completely free from nebulous appearance.

251 III. *Of stars with nebulosity of various shapes attached to them.*

252 Fourteen such objects noted.

Now, if we admit a contact between these nebulæ and the stars, it deserves to be remarked that stars in the situation of these fourteen cannot have been formed from their adjoining nebulosities; for a gradual condensation of the nebulous matter would have been central; whereas the stars are at the extremity of the nebulæ. Their connection is then due to some motion either of the star or of the nebulæ. If the nebulosity should subside into the star, it would give an idea of the *growth* of a star.

253 IV. *Of stars with nebulous branches.*

Three cases noted of a connection between stars and nebulæ, and reference made to *Phil. Trans.*, 1811, pp. 301–311, for further examples.

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1814 104 254 The idea of a nebula with a nucleus which gradually assumed the lustre of a star is more probable than the fortuitous central meeting of a star and nebula:

V. *Of nebulous stars.*

Thirteen are noted—see also *Phil. Trans.*, 1791, p. 71.

255 Nebulous stars are not only connected with a nebulosity, which, from its great regularity, might be taken for an atmosphere, but also with the luminous appearances belonging to the nebulous matter which is so widely expanded in various regions of the heavens.

What has been said of the gradual condensation of the nebulous matter in the case of extended nebulæ, is supported by a much greater number of nebulosities in a spherical form. [See *Phil. Trans.*, 1811, pp. 301–8.] 322 cases are there mentioned, in which the fact of the gradual condensation is rendered so evident as not to admit of a doubt.

256 Nebulous stars only differ from round nebulæ containing a nucleus in the degree of condensation.

256 VI. *Of Stars connected with extensive windings of nebulosity.*

Three cases noted. The nebulosity which has been shown to be connected with stars, may be fully proved to be of the same nature as the general mass of nebulous matter.

Stars of this class are in a condition of growth.

257 Possibility that stars were originally formed by a condensation of the nebulous matter.

We may conceive both the generation and growth of stars to be the legitimate effects of the law of gravitation, to which the nebulous matter is proved by observation to be subject.

VII. *Of small patches consisting of Stars mixed with nebulosity.*

Thirty-seven cases noted.

The connection may be only apparent—admitting it to be real:

1st, it may happen that the nebulosity still mixed with the stars is some remaining unsubsided part of that from which they were formed; or, 2d, the union of stars and nebulosity may have been affected by the motion of either the stars or the nebulosity.

258 Such motions do take place. Nebulæ are subject to great changes in their appearance, as the nebula of *Orion*. [*Phil. Trans.*, 1811, p. 320.]

259 Every nebulosity which is carried into the region of a small patch of stars will probably be gradually arrested and absorbed by them, and the *growth of stars* thus continued.

VIII. *Of objects of an ambiguous construction.*

Clusters of stars at a great distance may assume a nebulous appearance. [*Phil. Trans.*, 1811, p. 270.]

Telescopes of gradually increasing space-penetrating powers show certain objects successively as nebulæ, mixtures of nebulosity and stars, and as true clusters; other objects, so viewed, increase in brightness, and the nebulosity becomes more uniformly united and of a milky appearance, and these are purely nebulous.

260 Definition of *ambiguous* objects, their classification and examples. Seventy-one such noted in four classes.

Class 1. Seven objects, which may be supposed to consist of stars, but where observations leave it doubtful.

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1814 104 261 *Class* 2. Twenty-six objects of round or nearly round figure. The round figure of these show them to be *globular.* They must either be in a condensed state purely nebulous, or else, if consisting of stars, they must be in an advanced order of compression, and only appear nebulous on account of their very great distance from us.

A middle state between the progressive condensation of a globular nebula and a cluster of stars can have no existence, because a globular nebulosity when condensed can only produce a single star. A globular cluster may, however, intercept a mass of nebulous matter in motion, in which case the nebulosity must soon assume the form of the cluster, and will finally be absorbed by it.

Class 3. Twenty-six easily resolvable objects.

262 *Class* 4. Twelve objects, probably clusters.

IX. *Of the sidereal part of the Heavens.*

Intimate connection between the nebulous and sidereal condition.

263 Stars of first magnitude. [See *Phil. Trans.*, 1785, p. 68.]

264 Prismatic analysis of the light of *Sirius, α Orionis, Procyon, Arcturus, Aldebaran and α Lyræ.*

265 X. *Of the aggregation of stars.*

Star-gauges prove that the stars are not equally distributed over the celestial regions. [See *Phil. Trans.*, 1785.]

Forming clusters. This tendency to clustering is chiefly visible in places extremely rich in stars. Its greatest effects will then be in and near the milky way.

266 The twenty objects referred to are not given as instances of the actual formation of clusters, but merely to draw attention to a seemingly aggregating arrangement. Fifteen of these are in the milky way and five are near it.

266 XI. *Of irregular clusters.*

Clusters in very rich parts of the heavens are generally of irregular form and imperfectly collected. One hundred and twelve such ob-
267 jects are referred to; eighty of size not noted, fifty-three of these in the milky way, eighteen near it, nine at a distance from it. Also thirty-two irregular clusters from 2′ to 30′ in diameter; of these twenty-two are in the milky way and ten near it.

267 The great number of clusters in these two collections is not only an indication that they owe their origin to a clustering power residing in the centre; but the still remaining irregularity of their arrangement additionally proves that the action of the clustering power has not been exerted long enough to produce a more artificial construction.

268 XII. *Of clusters variously extended and compressed.*

Fifteen extended clusters named; twelve in the milky way, three near it. Their descriptions show that the power which has drawn the stars together has acted under different circumstances in the several cases.

269 XIII. *Of clusters of stars of a peculiar description.*

Six such objects named: one in the milky way, three near it, two at a distance from it.

271 XIV. *Of differently compressed clusters of stars.*

I have hitherto only considered the arrangement of stars in clusters with a view to point out whether they are drawn together by a clustering power in the same manner as the nebulous matter has

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been proved to be condensed by a gravitating principle; but in the forty-one clusters of the following two collections we shall see that it is one and the same power uniformly exerted which first condensed nebulous matter into stars and afterwards draws them together into clusters, and which, by a continuance of its action, gradually increases the compression of the stars which form the clusters. The first collection has thirty-three considerably compressed clusters, seventeen in the milky way, fifteen near it, and one at a distance. The second collection contains eight clusters, highly compressed, five in the milky way, two near it, and one at a distance.

1814 104 272 XV. *Of the gradual concentration and insulation of clusters of stars.*

The existence of a clustering power is nowhere so visibly pointed out as in the thirty-nine clusters given in the following collection: Twenty-one of these are in the milky way, seven near it, and eleven at a distance.

273 XVI. *Of globular clusters of stars.*

Fourteen such objects noted: One in the milky way, four near it, and nine at a distance from it.

274–7 [Detailed accounts from observing books of M. 72; M. 2; M. 5; M. 56; M. 80; M. 13; M. 3; M. 15; M. 79; M. 19; M. 53.]

278 XVII. *Of more distant globular clusters of stars.*

The following eleven objects are so like those of the foregoing collection that I have called them miniatures of the former. Five of these are in the milky way, one near it, and five at a distance. Detailed descriptions given.

279 I have supposed the clusters of this class to be at a greater distance from us than those of the preceding collection, because the stars of which they are composed are more minute than those of the clusters of which I have called them miniatures; their compression is also closer, and the size of the whole is much contracted, all of which particulars are readily explained by admitting them to be more distant. This argument, however, does not extend so far as to exclude a real difference which there may be in different clusters, not only in the size, but also in the number and arrangement of the stars.

XVIII. *Of still more distant globular clusters of stars.*

280 It has frequently happened that I saw three objects in succession, the first of which was a brilliant globular cluster of stars, the second a miniature of the former in which the stars could just be perceived, and the third in every respect a similar miniature of the second, as the second was of the first, but in which the stars, though suspected, were no longer to be distinguished. Five such objects given, all in the milky way.

XIX. *Of a recurrence of the ambiguous limit of observation.*

281 It has already been shown [VIII, p. 259] that in passing from faint nebulosity to the suspected sidereal condition we cannot avoid meeting with ambiguous objects, and the same critical situation will again occur, when, from the distinctly sidereal appearance, we endeavor to penetrate gradually further into space.

The effects of clustering power have been gradually traced from the first indication of clustering stars through irregular as well as through more artificially arranged clusters up to the beautiful globular form.

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The extended views I have taken in this and in my former papers of the various parts that enter into the construction of the heavens have prepared the way for a final investigation of the universal arrangement of all these celestial bodies in space. The *scale* is still wanting by which distances are to be measured.

1814 104 282 XX. *Of the breaking up of the Milky Way.*

Its whitish tinge has been proved by star-gauges to arise from accumulated stars. It does not now consist of equally scattered stars.

283 One hundred and fifty-seven instances have been given of clusters situated within the milky way. Sixty-eight more are in the borders. Now, since the stars of the milky way are permanently exposed to the action of a power whereby they are irresistibly drawn into groups, we may be certain that from mere clustering stars they will be gradually compressed through successive stages of accumulation till they come up to what may be called the ripening period of the globular form, and total insulation; from which it is evident that the milky way must be finally broken up and cease to be a stratum of scattered stars.

The state into which the incessant action of the clustering power has brought it at present is a kind of chronometer that may be used to measure the time of its past and future existence; and although we do not know the rate of going of this mysterious chronometer, it is
284 nevertheless certain that since the breaking up of the milky way affords a proof that it cannot last forever, it equally bears witness that its past duration cannot be admitted to be infinite.

This paper is accompanied by Plate IX, p. 284, with 17 figures.

Fig. 1 = H. v, 46.
2 = H. iii, 67.
3 = H. ii, 706,
4 = H. i, 143.
5 = H. iv, 4.
6 = H. iv, 35.
Fig. 7 = H. iv, 42.
8 = H. iv, 69.
9 = H. iv, 33.
10 = H. iii, 697.
11 = H. ii, 101.
12 = H. ii, 500.
Fig. 13 = H. viii, 44.
14 = H. viii, 4.
15 = H. vi, 36.
16 = H. vi, 5.
17 = M. 72.

1815 105 293 *A series of observations of the satellites of the Georgian planet, including a passage through the node of their orbits; with an introductory account of the telescopic apparatus that has been used on this occasion; and a final exposition of some calculated particulars deduced from the observations.* By WILLIAM HERSCHEL, LL. D., F. R. S. Read June 8, 1815.

293 A telescope suitable to examine these faint objects must possess the double power of magnifying and penetrating into space.

294 The *effective* magnifying power defined.

A 10-foot reflector, even with its highest powers, will not show these objects.

295 The machinery of my 20-foot telescope is so complete that I have been able to take up the planet at an early hour in the evening and to follow it for 7, 8, or 9 hours successively. The 40-foot telescope has not been always used because time is required for preparations. The temperature is often too changeable; its use requires 2 workmen, beside the assistant at the clock and writing-desk.

296 The 20-foot can be pointed on the planet with everything adjusted in 10 minutes.

206 It has constantly been a rule with me not to observe with a larger instrument when a smaller would answer.

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I have two mirrors for the 20-foot always ready, and my observations are never interrupted by accidents, which often happen to large mirrors, such as greatly injure their polish.

1815 105 296 In these delicate observations no double eye-glass should be used, as we have a waste of light at four surfaces instead of two.

297 The hole through which the rays pass to the eye should be much larger than the diameter of the optic pencils and considerably nearer the glass than their focus, for the eye ought on no account to touch the eye-piece.

297 With regard to the eye-glasses when merely the object of saving light is considered, I can say from experience that concaves have greatly the advantages of convexes, and they give also a much more distinct image. This fact I established by repeated experiments about 1776. For the cause of the superior brightness and sharpness of the image which is given by concaves we must probably look to the circumstance of their not permitting the reflected rays to come to a focus. Perhaps a certain mechanical effect, injurious to distinctness, takes place at the focal crossing of rays in convex lenses.

297 [Foot-note.] [An experiment to test this described. It was inconclusive.]

298 The satellites were discovered with a magnifying power of 157 only.

299 Magnifiers of 300, 460, 600, and 800 have been used, according to the conditions of the mirror, atmosphere, etc. On particular occasions 1,200 was used, and 2,400, 3,600, and 7,200 have been used to scrutinize the closest neighborhood of the planet. The known satellites began to be nebulous with these powers.

299 In the following observations the positions of the satellites have been determined in 3 ways: Coarse estimations, aided by diagrams; more careful ones, aided by a wire in the focus of the eye-glass; and micrometer measures.

301 Distances were more difficult to measure than angles of position.

302 The following observations are given in the order of the time they were made. They contain everything that relates to the two large satellites and to the researches for detecting additional satellites.

That such there are I have no doubt.

303 After each observation is given an "identification" which shows by computation the places of the known satellites.

304 The configurations made at the time of observation are not given. They generally contained the planet, its satellites and some of the neighboring stars, especially those that were in the path of the planet.

304 *Observations of the satellites of the Georgian planet, accompanied by a theoretical determination of their situation, whereby their identity may be ascertained.* [From 1787, Jan. 11, to 1810, May 25.]

322 [Foot-note.] Telescopic vision in windy weather is generally very perfect.

343 *Investigation of several particulars deduced from the foregoing observations, with an exposition of the method by which they have been obtained.*

344 *The place of the ascending node, the inclination of the orbits and the retrograde motions of the satellites determined.*

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1815 105 345 *Consideration of the principles by which the periodical revolution of the satellites may be obtained from the observed angles of position.*

348 *The periodical revolutions of the satellites determined.*

350 The *first satellite* [*Titania*] makes a synodical revolution in $8^d\ 16^h\ 56^m\ 5.2^s$ and the *second* [*Oberon*] in $13^d\ 11^h\ 8^m\ 59^s$.

351 *Explanation of the identifying method.*

355 I. With the light of my 20-foot telescope the first satellite generally becomes invisible at a distance of [18″] from the planet; and

II. The second at about [24″].

III. An interior satellite cannot be seen two nights in succession.

356 IV. Exterior satellites that are very faint when at their greatest elongation can hardly ever be seen at any other time when the orbits are contracted.

V. [*Titania*] is probably larger than [*Oberon*].

VI. Both are subject to great variations of light [not owing to the changeable clearness of the air].

VII. This may be due to a rotation on their axes, or from atmospheres.

VIII. I have supposed the distances of the first and second satellites to be 36″ and 48″ respectively.

IX. The existence of additional satellites has been considered already in *Phil. Trans.*, 1798, p. 59.

358 *An interior satellite.*

359 *Addition* [in regard to an interior satellite].

360 *An intermediate satellite. An exterior satellite;* and *Addition.*

361 *More distant satellites;* and *Addition.*

362 Plate XVI, diagram.

1817 107 302 *Astronomical Observations and Experiments tending to investigate the local Arrangement of the Celestial Bodies in Space and to determine the Extent and Condition of the Milky Way.* By Sir WILLIAM HERSCHEL, *Knt. Guelp.*, LL. D., F. R. S. Read June 19, 1817.

302 The construction of the heavens can only be known when we have the situation of each body defined by its three dimensions. Of these three the ordinary catalogues give but two, leaving the distance or profundity undetermined.

303 The method of parallaxes has given the distance of the sun, planets, etc. The parallax of the stars has also received attention. With regard to more distant objects, as small stars, compressed clusters, and nebulæ, these methods can give us no assistance.

303 I. *Of the local situation of the stars of the Heavens.*

304 It is evident that we cannot mean to affirm that the stars of the fifth, sixth, and seventh magnitudes are really smaller than those of the first, second, or third, and that we must ascribe the cause of the difference in the apparent magnitudes of the stars to a difference in their relative distances from us. On account of the great number of stars in each class we must also allow that the stars of each succeeding magnitude beginning with the first, are, one with another, further from us than those of the magnitude immediately preceding. The relative magnitudes give only relative distances, and can afford no information as to the real distances at which the stars are placed.

304 II. *Of a standard by which the relative arrangement of the stars may be examined.*

A standard of reference for the arrangement of the stars may be had

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by comparing their distribution to a certain properly modified
equality of scattering. The equality which I propose does not re-
1817 107 305 quire that the stars should be at equal distances from each other,
nor is it necessary that all those of the same nominal magnitude
should be equally distant from us.

305 It consists in allotting a certain equal portion of space to every star, in consequence of which we may calculate how many stars any given extent of space may contain.

This arrangement is explained by means of a figure. Plate XV, Fig. 1.

306 III. *Comparison of the order of magnitudes with the order of distances.*

Comparison of the order of distances by the foregoing scheme with the magnitudes assigned in BODE's catalogue of 14,144 stars.

308 The result of this comparison is, that if the order of magnitudes could indicate the distance of the stars, it would denote at first a gradual, and afterwards a very abrupt, condensation of them; but that, considering the principle on which the stars are classed, their arrangement into magnitudes can only apply to certain relative distances, and show that, taking the stars of each class, one with another, those of the succeeding magnitudes are farther from us than the stars of the preceding order.

308 IV. *Of a criterion for ascertaining the profundity or local situation of celestial objects in space.*

309 It will be admitted that those stars, the light of which we can experimentally prove to be $\frac{1}{4}$, $\frac{1}{9}$, $\frac{1}{16}$...... of the light of any certain star of the first magnitude must be 2, 3, 4......times as far from us as the standard star, provided the condition of the stars should come up to the supposed mean state of diameter and lustre of the standard star.

309 V. *Of the equalization of star light.*

309 Star gauging gave rise to an investigation of the space-penetrating power of telescopes.

310 Finding that this might be calculated with reference to the extent of the same power of which the unassisted eye was capable, there always remained a desideratum of some sure method by which this last might be ascertained.

Description of experimental apparatus.

311 Method of limiting apertures described.

313 VI. *Of the extent of natural vision.*

313–8 Experiments on stars made in August and December, 1803, and February, 1814.

314 *Arcturus* has four times the light of *α Andromeda*, *Polaris*, *γ Ursæ*, and *δ Cassiopeæ*. *α Andromeda* is four times as bright as *μ Pegasi*, etc., etc.

316 Table of proportional light of stars of various orders.

318 The distances of clusters cannot be ascertained by the method of equalizing star light.

VII. *Of the extent of telescopic vision.*

319 Experiments which go to show that the diameter of the pupil of the human eye is not more than 0.21 inch, and is greater than 0.17 inch when observing with a telescope. It may be assumed 0.2 inch.

320 VIII. *Application of the extent of natural and telescopic vision to the probable arrangement of the celestial bodies in space.*

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We shall be able to say that a distant celestial object is so far from us, provided the stars of which it is composed are of a size and lustre equal to the size and lustre of such stars as *Sirius*, *Arcturus*, etc.

1817 107 321 The stars of the tenth, eleventh, and twelfth order of distances are not only more compressed than those in the neighborhood of the sun, but, moreover, their compression in different parts of the heavens must be very unequal.

IX. *Of the construction and extent of the milky way.*

322 General description of it.

The sun is within its plane, for to an observer in latitude 60°, when at 100° R. A. the milky way is in the east, it will at the same time be in the west at 280°; while in its meridional situation it will pass through *Cassiopeia* in the Zenith and through the constellation of the Cross in the Nadir.

323–4 Examination of the cluster in the Sword Handle of *Perseus*, with various space-penetrating powers.

325 [Beside the 863 gauges published in *Phil. Trans.*, 1785, p. 221, above 400 more have been taken in various parts of the heavens and are not published.]

326 The twenty-foot telescope cannot fathom the profundity of the milky way.

326 If the stars of the 5th, 6th, and 7th magnitudes cannot be supposed to be gradually of a smaller physical size and brightness than those of the 1st, 2d, and 3d, how much less can a supposition be admitted that would require that the stars which, by a long series of gauging powers, have been proved to make their gradual telescopic appearance should also be gradually of a different construction with regard to physical size and brightness from those which we see with the naked eye?

327 The telescopic breadth of the milky way considerably exceeds the extent which, in our maps, is assigned to it.

328–30 Observations—sweeps—which confirm this.

330 X. *Concluding Remarks.*

What has been said of the extent and condition of the milky way in my papers on the construction of the heavens, with the addition of this attempt to give a more correct idea of its profundity in space, will contain nearly all the general knowledge we can ever have of this magnificent collection of stars.

331 Our sun with all the stars we can see with the eye are deeply immersed in the milky way, and form a component part of it.

WILLIAM HERSCHEL.

[Dated] Slough, near Windsor, May 10, 1817.

1818 108 429 *Astronomical observations and experiments, selected for the purpose of ascertaining the relative distances of clusters of stars, and of investigating how far the power of our telescopes may be expected to reach into space when directed to ambiguous celestial objects.* By Sir WILLIAM HERSCHEL, *Knt. Guelp.*, LL. D., F. R. S. Read June 11, 1818.

429 The method of equalization of star light will show the relative distances of stars; from this a method was explained in *Phil. Trans.*, 1817, by which means the profundity in space of every object consisting of stars can be ascertained as far as the light of the telescope

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suffices. This method may be used to ascertain the profundity of globular and other clusters.

1818 108 430 I. *Of the distance of globular and other clusters of stars.*

General principles to guide in such observations.

431 II. *A series of observations of clusters of stars from which the order of their profundity in space is determined.*

431–51 Observations of H. vi, 7, 9, 10, 11, 12, 17, 20, 26, 35, 38, 41, 63, and of M. 1, 2, 3, 4, 5, 9, 10, 11, 12, 13, 14, 15, 19, 22, 30, 33, 34, 35, 53, 55, 56, 57, 62, 67, 68, 69, 71, 72, 74, 75, 77, 79, 80, 92, 97.

451 III. *Of a method to represent the profundity of celestial objects in space by a diagram.*

470 Fig. 1, Plate xxi, represents such a method applied to the foregoing objects.

460 IV. *Of ambiguous celestial objects.*

An object is often ambiguous when viewed with insufficient optical means, and its nature may be known by increasing this means. Objects ambiguous to the naked eye become known with the 20-foot telescope, and so on.

462 V. *The milky way, at the profundity beyond which the gauging powers of our instruments cannot reach, is not an ambiguous object.*

463 We may conclude that when our gauges will no longer resolve the milky way into stars it is not because it is ambiguous, but because it is fathomless.

463 VI. *Of the assumed semblance of clusters of stars when seen through telescopes that have not light and power sufficient to show their nature and construction.*

464 Observations of various clusters in telescopes of various sizes.

465 Two different principles, the *nebulous* and the *sidereal*, have been observed in the celestial spaces.

Distinguishing characteristics of each.

466 It seems highly probable that some of the cometic, many of the planetary, and a considerable number of the stellar nebulæ, are clusters of stars in disguise.

466 VII. *Of the extent of the power of our telescopes to reach into space when they are directed to ambiguous celestial objects.*

The method of equalizing the light of stars may be applied so as to give an estimate of the extent of this power.

When the united light of a cluster of stars is visible to the [naked] eye, there will be a certain maximum of distance to which the same cluster might be removed, so as still to remain visible in a telescope of a given space-penetrating power; and if the distance of the cluster can be ascertained by the gauging power of any instrument, that will just show the stars of it, the order of the profundity at which this cluster could still be seen as an ambiguous object may be ascertained by the space-penetrating power of the telescope through which it is observed.

467–70 Examples of this method.

470 Plate XXI.

WILLIAM HERSCHEL.

[Dated] Slough, near Windsor.

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REPORTS OF ASTRONOMICAL OBSERVATORIES.

In the latter part of the year 1880 the following circular was sent to all known observatories in America and to a number of foreign establishments:

[Circular.]

SMITHSONIAN INSTITUTION,
Washington, D. C.

MY DEAR SIR: It is desired to present in the annual report of this institution a yearly summary of the state and progress of astronomy in the United States and elsewhere. To this end it is requested that the directors of observatories, public and private, will return this circular, with the blanks filled out, and with such additional information as they may deem suitable for publication.

It is intended that one such circular shall reach every observatory, public or private, in the United States; if any have been omitted it has been by inadvertence, and notice of such omissions is desired by the editor (Prof. EDWARD S. HOLDEN, U. S. Naval Observatory, Washington, D. C.).

It is proposed to continue the summaries in the future, and it is hoped that the directors of the various institutions will desire to furnish from year to year brief sketches of the activity of the observatories under their charge. In this way a record of current astronomical work will be kept up, which otherwise it is difficult to maintain in the absence of any American periodical specially devoted to astronomy.

Very truly yours,

SPENCER F. BAIRD,
Secretary Smithsonian Institution.

To ——— ———.

The information asked for embraced: I. The *Personnel:* II. The *Instruments* employed: (*a*) Meridian circles; (*b*) (*b'*) Meridian transit instruments; (*c*) (*c'*) Equatorial instruments; (*d*) Spectroscopes; (*e*) Photomers and other subsidiary apparatus; (*f*) Chronographs; (*g*) Clocks; (*h*) Chronometers; (*i*) Miscellaneous instruments: III. The character of observations made or contemplated.

Replies to this circular received up to March 15, 1881, are given below, in two classes: Reports of American observatories, and reports of Foreign observatories. Additional information of a statistical nature has been obtained from an article in the *Annuaire de l'Observatoire Royale de Bruxelles*, 1881; which has been translated by Miss Lockwood.

In the absence of Professor Holden (at the Washburn Observatory, Wisconsin) Mr. George H. Boehmer, of the Institution, has attended to the arrangement and editing of these Notices.

I. AMERICAN OBSERVATORIES.

ALBANY, *New York.*

Dudley Observatory.

Longitude from Washington, 13ᵐ 12ˢ.87 E.
Latitude, 42° 39′ 49″.5 N.
Directors: B. A. GOULD, 1854;
O. M. MITCHEL, 1859;
G. W. HOUGH, 1862;
L. BOSS, 1875.

Founded in 1851, by subscription, the principal subscriber being Mrs. BLANDINA DUDLEY. Built in the form of a cross, with wings east and west for the meridian instruments. Finished in 1854, and inaugurated in 1856.

ALFRED, *Alleghany County, New York.*

Alfred Observatory.

Longitude from Washington, 2ᵐ 55ˢ. W.
Latitude, 42° 15′ 19″.8 N.
Director: ——— ——— ?

ALLEGHANY CITY, *Pennsylvania.*

Alleghany Observatory.

Longitude from Washington, 11ᵐ 50ˢ.84 W.
Latitude, 40° 37′ 47″.6 N.
Director: S. P. LANGLEY.
Assistant: F. W. VERY.

Founded in 1860 as an annex to the University; completed in 1867 through the liberality of W. SHAW. The dome, 26½ feet (eight meters) in diameter, contains an equatorial.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* makers, TROUGHTON & SIMMS; aperture, 4 inches; magnifying power, 150 diameters.

(*c*) *Equatorial instrument:* maker, FITZ, re-worked by CLARK; aperture of objective, 13 inches; magnifying powers of eye-pieces, 50 to 1200; equatorial carries a 12-inch flat mirror by CLARK at south end of its polar axis; also, position filar micrometer, polarizing solar eye-piece; apparatus for projecting solar image; eight other subsidiary pieces.

(*d*) *Spectroscopes:* one employing large RUTHERFURD grating; one with small grating; one 2-prism spectroscope; apparatus for using large equatorial as collimator, &c.

(*e*) *Photometers and other subsidiary apparatus:* A variety of thermopiles, used in connection with a THOMPSON reflecting galvanometer; large BUNSEN photometer; small portable heliostat, &c.

(*f*) *Chronograph:* one of BOND'S pattern, built by HAMBLET.

(*g*) *Clocks:* two mean time; by HOWARD, both break-circuit: one sidereal; by FRODSHAM, break-circuit.

(*h*) *Chronometers:* one mean time; by FRODSHAM: one sidereal; FRODSHAM, break-circuit.

(*i*) *Miscellaneous:* One reflecting telescope of 6½-inch aperture, specially used for obtaining an image projected any size without the employment of any enlarging lenses, and a number of subsidiary pieces for investigations in heat and light. Electric appliances for the distribution of exact time, automatically and continuously to points outside the observatory.

The work of research during the past year has lain chiefly in measurements of the distribution of energy in the spectrum of the sun. The routine work of the time service has been continued.

WORK PROPOSED FOR THE COMING YEAR (1881):

(1.) The redetermination of the *solar constant.*

(2.) Redetermination of the law of the distribution of energy in the solar spectrum as it is observed after absorption by our terrestrial atmosphere.

(3.) Determination (for the first time) of the law of the absolute distribution of the solar energy, or in other words the construction of a curve showing the distribution of the solar energy as it would appear to an observer stationed *outside* of the earth's atmosphere.

Professor LANGLEY is now absent with a large party prosecuting his investigations on the solar constant, on one of the high mountains in Southern Nevada.

AMHERST, *Massachusetts.*

College Observatory.

Longitude from Washington, 18^{m} 4^{s}.8 E.
Latitude, 42° 22′ 15″.6 N.
Director: W. C. ESTY.
Founded in 1857 as an annex to the College.

ANN ARBOR, *Michigan.*

Detroit Observatory.

Longitude from Washington, 26m 43s.1 W.

Latitude, 42° 16′ 48″. N.

Directors: F. BRÜNNOW, 1854;
J. C. WATSON, 1858;
M. W. HARRINGTON, 1879.

Annex of the University of Michigan. Projected in 1852, commenced in 1853, completed in 1854. The principal structure is surmounted by a dome and has two wings. About thirty planetoids have been discovered there.

ANNAPOLIS, *Anne Arundel County, Maryland.*

U. S. Naval Academy Observatory.

Longitude from Washington, 2m 15s.61 E.

Latitude, 38° 58′ 53″.48 N.

Authority for latitude, Professor CHAUVENET; for longitude, United States Coast Survey.

Director: Lieut. Commander P. F. HARRINGTON, head of department of Astronomy, Navigation, and Surveying.

Assistants: 1. Lieut. Commander C. J. TRAIN, U. S. Navy;
2. Lieut. Commander R. P. RODGERS, U. S. Navy;
3. Lieut. W. J. BARNETTE, U. S. Navy.

INSTRUMENTS:

(*a*) *Meridian circle:* one; makers, REPSOLD, Germany; diameter of circles, 30 inches; divided to 2′; read by 4 microscopes to 2″. Aperture of objective, 4 inches; for observations of the sun, aperture employed, — inches; magnifying power ordinarily employed, 80 diameters.

(*b*) *Meridian transit instrument:* maker, WÜRDEMANN; aperture, 2 inches; magnifying power, 40 diameters.

(*c*) *Equatorial instrument:* makers, ALVAN CLARK & SONS; aperture of objective, 7¾ inches; magnifying power of eye-pieces, 40, 106, 553, and 966; micrometer eye-pieces, 89, 226, 673.

(*f*) *Chronographs:* one MORSE fillet; one Transit of Venus Commission.

(*g*) *Clock:* one sidereal; makers, ARNOLD, CHAS. FRODSHAM, London.

(*h*) *Chronometers:* five, mean time; makers, NEGUS, Nos. 1030, 1088, 1260; DENT, 2099; HATTON, 262: two sidereal; maker, NEGUS, Nos. 1520, 1527.

(*i*) *Miscellaneous:* one Talcott's zenith telescope (WÜRDEMANN); one Transit of Venus telescope (STACKPOLE); portable transit (WÜRDEMANN).

The officers attached to the observatory are not practical astronomers, and they are fully occupied in duties of instruction in the Department of Astronomy, Navigation, and Surveying. The instruments are used in the course of instruction, but regular observations are not made for purposes of astronomical investigation.

BATTLE CREEK, *Calhoun County, Michigan.*

High School Observatory.

Longitude from Washington, ——— ?
Latitude, ——— ?

Director: ARTHUR K. BARTLETT (private observer).

INSTRUMENTS:

(*a*) *Meridian circle:* one; aperture of objective, 4 inches; for observations of the sun, aperture employed, 2 to 4 inches; magnifying power ordinarily employed, 75 diameters.

(*i*) *Miscellaneous:* The only instrument at present used in the "Observatory" is a 4-inch achromatic telescope, which was purchased by the board of education, about nine years ago, for the use of students and teachers in the high school. It was manufactured by PIKE, the New York optician, and is mounted upon a portable tripod stand, provided with all the necessary adjustments. For the general observations of astronomy, it is regarded as one of the best telescopes in this State.

BETHLEHEM, *Pennsylvania.*

Bethlehem Observatory.

Longitude from Washington, $6^m\ 40^s.19$ E.
Latitude, 40° 36′ 23″.9 N.
Director: ——— ?

BROOKLYN, *New York.*

Private Observatory.

Longitude from Washington, ——— ?
Latitude, ——— ?

Director: G. P. SERVISS.

INSTRUMENTS:

(*c*) *Equatorial instrument:* maker, JOHN BYRNE, New York; aperture of objective, 3⅜ inches; magnifying powers of eye-pieces, 50 to 320. By a double concave, or Barlow, lens of 6 inches focus these powers are each about doubled, with slight loss of light. In use, five eye-pieces and a prism. Also, a common spy-glass of 1⅜ inches clear aperture, used for counting sun-spots and other observations; power, 25 diameters. By lengthening the eye-tube as described in DICK'S "Practical Astronomer" this power can be about doubled.

(*g*) *Clocks:* A good watch, and clock of ordinary construction.

OBSERVATIONS DURING THE PAST YEAR (from October, 1879, to March, 1881):

Observations of sun-spots; keeping a daily map of the sun, on which the positions and number of spots are denoted; a weather record kept in connection with observations of sun-spots; also, observations of the principal planets and the moon to detect physical changes; also, observations of nebulæ and star-clusters, and of double stars, for color. Attention has been given to making naked-eye estimates of the comparative brilliancy of the larger stars. As the result of a great many observations it is found that *Arcturus* slightly exceeds *Capella*, and that *Vega* is considerably inferior to both those named. This winter, for the first time, *Rigel* has seemed slightly superior to *Betelguese.*

WORK PROPOSED FOR THE COMING YEAR (1881):

Continuation of sun-spot observations in connection with a weather record; observations of the moon, planets, &c.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY:

Many editorial paragraphs and other articles on astronomical subjects in the New York Sun.

ADDITIONAL INFORMATION:

Since January 1, 1881, a daily record has been kept of the sunset colors and their intensity, on the supposition that such a record may possibly have some value for meteorological purposes. A record has also been kept of meteors and other celestial phenomena.

BROOKLYN, *New York.*

Private Observatory.

Longitude from Washington, ——— ?

Latitude, ——— ?

Director: W. T. GREGG.

(*c*) *Equatorial instrument:* maker, WILLIAM T. GREGG; aperture of objective, 6¼ inches; magnifying powers of eye-pieces, 50 to 600.

BUFFALO, *Erie County, New York.*

Private Observatory.

Longitude from Washington, $7^m\ 21^s.65$ W.

Latitude, 42° 54′ 9″.5 N.

Authority for latitude and longitude: Report for 1862 of the Regents of University of State of New York.

Director: HENRY MILLS.

INSTRUMENTS:

(*a*) *Telescope, not equatorial:* maker, BARDOU: aperture of objective, 3 inches: for observations of the sun, aperture employed, 3 inches; magnifying power ordinarily employed, 50 to 250 diameters.

OBSERVATIONS DURING THE PAST YEAR:

Observations on sun-spots and comets and such other celestial phenomena as come within the range of the instrument.

BUFFALO, *Erie County, New York.*

Private Observatory.

Longitude from Washington, ——— ?
Latitude, ——— ?
Director: JAMES W. WARD.
Assistants: Wife and friends.

INSTRUMENTS:

(*b*) *Meridian transit instrument.*

(*c*) *Equatorial instrument:* maker, JOHN BYRNE, New York City; aperture of objective, 4 inches; magnifying powers of eye-pieces, 60, 80, 130, 200, 330, 400; useful with Barlow lens to 550.

(*h*) *Chronometer:* one mean time; maker, SAMUELS, Liverpool.

(*i*) *Miscellaneous:* DOLLAND, 1¾ inches, used roughly on alt azimuth swivel for southern transits, &c.

OBSERVATIONS DURING THE PAST YEAR:

(*b*) Observations of Jupiter with memoranda; observations on the sun's spots; observations double stars and "sweeping"; observations searching the floors of the lunar plains.

WORK PROPOSED FOR THE COMING YEAR (1881):

As before, with illustrated astronomical instruction to a class of amateurs.

CAMBRIDGE, *Massachusetts.*

The Astronomical Observatory of Harvard College.

Longitude from Washington, $23^m\ 41^s.11$ E.
Latitude, 42° 22′ 48″.3 N.

Directors: W. C. BOND, 1831;
G. P. BOND, 1860;
J. WINLOCK, 1866;
EDWARD C. PICKERING, 1875.

Assistants: Miss R. G. SAUNDERS,
Miss S. C. BOND,

Mrs. ANNA WINLOCK,
Mrs. R. T. ROGERS,
W. V. BROWN,
A. W. CUTLER,
J. RAYNER EDMUNDS,
B. PICKMANN MANN,
WILLIAM A. ROGERS,
ARTHUR SEARLE,
FRANK WALDO,
O. C. WENDELL.

Annexed to Harvard College; projected in 1816; ground acquired in 1827; instruments set up in 1839; a central structure, with a great dome, two wings, two pavilions, surmounted by domes at the extremities of the wings. Here it was that G. P. BOND discovered in 1848 the seventh satellite of Saturn (*Hyperion*), and in 1850 the dusky interior ring inside the bright rings of that planet. This observatory possesses one of W. C. BOND'S chronographs, mounted in 1849, and an equatorial of 26¾ inches ($0^m.68$) aperture.

INSTRUMENTS:

(*a*) *Meridian circle:* makers, TROUGHTON & SIMMS (glasses by ALVAN CLARK & SONS); diameter of circles, 36 inches; divided to 5′; each circle read by 4 microscopes to 0″.1; aperture of objective, 8¼ inches: for observations of the sun, aperture employed, 8¼ inches; magnifying power ordinarily employed, 300 to 350 diameters. (*a′*) East transit circle, by TROUGHTON & SIMMS; diameter of circles, 48 inches; divided to 5′; each circle read by 4 microscopes to 0″.2; aperture of objective, 4¼ inches.

(*b*) *Meridian transit instruments:* one made by HERBST, of Pulkowa; aperture, 2¾ inches; magnifying power, up to 200 diameters. (*b′*) Large photometer, mounted in the meridian, for comparing images of stars during transit.

(*c*) *Equatorial instruments:* one made by MERZ; aperture of objective, 15 inches; magnifying powers of eye-pieces, 100 to 2000. (*c′*) West equatorial, by ALVAN CLARK & SONS; aperture, 5¼ inches.

(*d*) *Spectroscopes:* three, described in vol. viii of the Annals of the Observatory.

(*e*) *Photometers and other subsidiary apparatus:* One ZÖLLNER photometer, and several photometers of other kinds.

(*f*) *Chronographs:* two, spring governors, by W. BOND & SON; one small barrel chronograph.

(*g*) *Clocks:* one mean time; maker, BOND, 394: one sidereal; makers, FRODSHAM, 1327; BOND, 312.

(*h*) *Chronometers:* two sidereal; makers, FRODSHAM, 3451; BOND, 236; one thermometric chronometer, FRODSHAM, 3424.

(*i*) *Miscellaneous:* Comet-seeker and other small telescopes and apparatus.

OBSERVATIONS DURING THE PAST YEAR (from November 1, 1879, to November 1, 1880):

(*a*) Observations for clock error; determinations of absolute places of 109 stars; observations for difference of longitude, Cambridge and New Haven.

(*b*′) Photometric comparisons of stars visible to the naked eye; about 40,000 observations made.

(*c*) (*c*′) Micrometric and photometric observations of the satellites of Mars (including 1,103 position angles and 245 distances); photometric observations of 41 eclipses of Jupiter's satellites; observations of planetary nebulæ; discovery and examination of stars with unusual spectra; observations of variable stars, comets, asteroids.

WORK PROPOSED FOR THE COMING YEAR (1880–'81):

Continuation of observations now in progress.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR 1879–'80:

1. Annals of the Observatory, vol. xi, part i, 1879.
2. Annals of the Observatory, vol. xi, part ii, 1880.
3. Annals of the Observatory, vol. xii, 1880.
4. Thirty-fourth Annual Report, 1880.
5. E. C. PICKERING, Dimensions of the Fixed Stars, published in vol. xvi of the Proc. Amer. Acad., 1880.
6. W. A. ROGERS, Standards of length, published in vol. xv of the Proc. Amer. Acad., 1880.

CAMBRIDGEPORT, *Mass.*

Private Observatory.

Longitude from Washington, $23^m\ 49^s$ E., approximately.

Latitude, 42° 21′ 56″ N., approximately.

Director: E. F. SAWYER.

For the past four years the director has been principally engaged in recording meteoric observations, having published from time to time lists of bright meteors, stationary meteors, meteor showers, &c., and has also compiled two catalogues of "Radiant points of meteors," deduced from some 1,100 or 1,200 meteor tracks. Has also collected a series of observations on the variable stars *o Ceti*, *γ Aquila*, *β Lyræ*, *δ Cephei*, and *ρ Scuti*, &c., and, under the head of miscellaneous phenomena, has swept some for comets, &c. Observations have been published in the Astr. Nachrichten, Observatory, Monthly Notices, Science Observer, American Journal of Science, &c. During the coming year, generally the same field of observation will be occupied. Telescopic observations have been principally made with a 3⅜ inch BORDAN, on portable equatorial stand with divided circles, but no clock-work.

CHICAGO, *Cook County, Illinois.*

Dearborn Observatory.

Longitude from Washington, 42^{m} $14^{s}.69$ W.
Latitude, 41° 50′ 1″ N.
Directors: T. H. SAFFORD, 1865;
G. W. HOUGH, 1875.

Annexed to the University. Founded by subscription in 1822. In 1864 it came into possession of an equatorial of 18½ inches ($0^{m}.47$) aperture, made by ALVAN CLARK, with the assistance of which S. W. BURNHAM has made a close and most interesting study of many double stars.

INSTRUMENTS:

(*a*) *Meridian circle:* makers, REPSOLD & SON; diameter of circle, 40 inches; divided to 2′; read by 4 microscopes to 0″.1; aperture of objective, 6 inches; for observations of the sun, aperture employed, 3 inches.

(*c*) *Equatorial instrument:* makers, ALVAN CLARK & SONS; aperture of objective, 18½ inches; magnifying powers of eye-pieces, positive, 120, 190, 287, 385, 900; negative, 135, 225, 450, 900.

(*f*) *Chronograph:* G. W. HOUGH; cylinder recording.

(*g*) *Clocks:* one mean time; makers, HOWARD & CO.; GRAHAM escapement, mercury pendulum: one sidereal: makers, CHARLES GORTNER & CO., London; GRAHAM escapement, mercury pendulum.

(*h*) *Chronometer:* sidereal; makers, BOND & SON.

(*i*) *Miscellaneous:* signal mean time clock for transmitting time signals.

OBSERVATIONS DURING THE PAST YEAR (from January, 1880, to March 1, 1881):

(*a*) REPSOLD meridian circle. Observations for "Time."

(*c*) Micrometer observations of the satellites of Uranus. Micrometer observations on the planet Jupiter. (1) Great red spot; longitude, latitude, length, breadth, &c. (2) Equatorial white spots; longitude, latitude, length. (3) Miscellaneous spots; longitude, latitude, length. (4) Position and magnitude of the equatorial belt. (5) Position and magnitude of the faint belts. (6) Physical observations. Comet observations for positions. Miscellaneous work.

WORK PROPOSED FOR THE COMING YEAR (1881):

Satellites of Uranus.
Jupiter continued.
Miscellaneous.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR 1880:

G. W. HOUGH, Report of the Director. Pamphlet.
Satellites of Uranus. Astron. Nachr.
Red spot on Jupiter. Astr. Register.
Observing seat for the equatorial. Monthly Notices.

ADDITIONAL INFORMATION:

The great equatorial has been used as heretofore by Mr. S. W. BURNHAM for double-star observations. His report is appended.

Report of S. W. Burnham.

Number.	Title.	Published in—	Volume.	Page.
1	An examination of the double star measures of the Bedford catalogue.	Monthly Notices of the Royal Astronomical Society.	XL	497–532
2	The discovery of κ Pegasi as a close double star..	Monthly Notices........	XLI	33
3	The binary star, β Delphini........................	......do	XLI	....
4	New double star, σ Aurigæ........................	Observatory	III	451
5	The multiple star, P. xxiii, 100 (OΣ 496)	......do	III	568
6	Notes on double stars..............................	......do	III	408
7	New double star, 5 Persei..........................	......do	III	582
8	ζ Lyræ	......do	IV	18
9	40 Leonis Minoris, new double.....................	Astronomical Register..	XVIII	140
10	New double star, 9 Persei..........................	......do	XVIII	286
11	The double star, Σ 2318	......do	XVIII	113
12	The double star, Σ 2789	......do	XVIII	286
13	ψ^1 Aquarii	......do	XIX	41
			Number.	
14	Measures of the companion of Sirius...............	Astronomische Nachrichten.	2314	....
15	The double star, 85 Pegasi (β 733)	......do	2319, 2334	....
16	ζ Sagittarii	......do	2338	....
17	δ Equulei (OΣ 535)	......do	2340	....
18	OΣ 367 and OΣ 7....................................	......do	2341	....

The observations during the year comprise about 800 micrometrical measures of previously-known double stars, and the discovery of about 70 new pairs, the most of which have been measured on three or four different nights each. A number of prominent naked-eye stars, some of which are mentioned in the contributions to astronomical periodicals, are included in the list of new stars. Careful series of measures of many of the most difficult of the binary systems have been made, and particularly those requiring a large aperture from the extreme closeness of the components, or the faintness of the companion star.

CINCINNATI, *Ohio.*

Cincinnati Observatory (?).

Longitude from Washington, $29^{m}\ 46^{s}.85$ W.
Latitude, 39° 6′ 26″.5 N.
Director: ——— ?

CLINTON, *Oneida County, New York.*

Litchfield Observatory of Hamilton College.

Longitude from Washington, $6^{m}\ 34^{s}.65$ E.
Latitude, 43° 3′ 17″ N.

Authority for longitude: Longitude telegraphically determined from Cambridge, Mass. Latitude by stars in prime vertical.

Director: C. W. F. PETERS.

Founded in 1852, by subscription; completed in 1855; central edifice with wings east and west. Forty-two planetoids have been discovered here.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* maker, W. WÜRDEMANN, Washington, D. C.; aperture, 2½ inches; magnifying power, — diameters.

(*c*) *Equatorial instrument:* one made by SPENCER & EATON; aperture of objective, 13½ inches; magnifying powers of eye-pieces, 80 to 1600. (*c′*) One by STEINHEIL SONS; aperture, 4 inches. (*c″*) One by HUGO SCHRÖDER; aperture, 5 inches.

(*d*) *Spectroscope:* one direct vision 5 prisms; attached to the 4-inch STEINHEIL refractor.

(*f*) *Chronograph:* by WM. BOND & SON, Boston, Mass.

(*g*) *Clocks:* mean time; makers, WM. BOND & SON.

(*h*) *Chronometer:* sidereal; makers, WM. BOND & SON

OBSERVATIONS DURING THE PAST YEAR:

(*b*) (*b′*) Determination of time.

(*c*) Observations of minor planets, comets, &c.; positions of fixed stars determined in zones; charting.

(*c′*) (*c″*) Practicing by students of astronomy.

WORK PROPOSED FOR THE COMING YEAR (1881):

Continuation of work of preceding years.

COLUMBIA, *Boone County, Missouri.*

The Laws Observatory, University of the State of Missouri.

Longitude from Washington, $1^h\ 1^m\ 6^s$ W.

Latitude, 38° 56′ N.

Authority for latitude and longitude: JOSEPH FICKLIN and THOMAS J. LOWRY.

Director: JOSEPH FICKLIN.

Assistants: THOMAS J. LOWRY,
WM. A. CAUTHORN.

INSTRUMENTS:

(*a*) *Meridian circle:* one; maker, BRUNNER, of Paris; diameter of circle, 10½ inches; divided to 5′; read by two microscopes to 3″; aperture of objective, $2\frac{1}{16}$ inches; for observations of the sun, aperture employed, $2\frac{1}{16}$ inches; magnifying power ordinarily employed, 50 diameters.

(*c*) *Equatorial instruments:* one made by HENRY FITZ, of New York; aperture of objective, $4\frac{1}{16}$ inches; magnifying powers of eye-pieces, 30 to

240: one made by **MERZ & SON**, of Munich; aperture of objective, 7½ inches; magnifying powers of eye-pieces, 80 to 1018. This instrument is furnished with a micrometer, reflecting prisms, and sun-shades. It is driven by clockwork. The hour circle is 10 inches in diameter. It is graduated on silver to single minutes, and reads by two verniers to 4 seconds of time. The declination circle is 15 inches in diameter. It is graduated on silver to 10 minutes, and reads by two verniers to 10 seconds of arc. The finder was made by **ALVAN CLARK & SONS**, of Cambridgeport, Mass. It has an aperture of 1⅞ inches and a focal length of 17½ inches.

(*g*) *Clocks:* one mean time; maker, **RIGGS**, of Philadelphia: one sidereal; makers, **GREGG & RUPP**, of New York.

(*i*) *Miscellaneous:* The instrumental equipment includes also a sextant made by **E. & G. W. BLUNT**, of New York; the arc is graduated on silver, and reads by a vernier and microscope to 10 seconds. An alt-azimuth instrument, made by **E. & G. W. BLUNT**; it has an aperture of 2½ inches; the circles are 12 inches in diameter, and graduated to 10 minutes; the horizontal circle has four verniers with microscopes and the vertical circle two, and each reads to 10 seconds. A Transit theodolite, made by **GREGG & RUPP**, of New York.

OBSERVATIONS DURING THE PAST YEAR:

(*a*) The *meridian circle* has been used for *time observations* only.

(*c*) (*c′*) *Equatorial:* Observations on **HARTWIG'S** comet; observations on **SWIFT'S** comet.

WORK PROPOSED FOR THE COMING YEAR (1881):

1. The ordinary work of instruction to classes in astronomy.
2. Observations for time.
3. Observations on such new planets and comets as may be announced.

During February and March, 1880, the old observatory building, which stood a few feet west of the main university edifice, was moved and enlarged. It now stands on the beautiful eminence in the campus near the chalybeate spring. The meridian line of each pier now passes between the university building and the president's mansion. In this position a good horizon is secured. In the old position the horizon was obstructed on the north by the scientific building, and on the east by the university building.

The old dome was found to be too small for the equatorial recently purchased, and a brick addition was made at the east end for the accommodation of this instrument. The whole building is 63 feet long from east to west, and fronts east.

The present greatly improved condition of the Observatory is due to the liberality of the president, Dr. S. S. **LAWS**, who, for the advancement of astronomical science, has given to the university more than $2,000 in order to procure the telescope and put it in complete working order, and to move and enlarge the observatory building.

COLUMBUS, *Franklin County, Ohio.*

Private Observatory.

Longitude from Washington, 23m 54s W.

Latitude, 40° 0′ 1″.5 N.

Authority for latitude and longitude: Coast Survey for State-house dome, a couple of miles or so distant.

Director: R. W. MCFARLAND.

INSTRUMENTS:

(*c*) *Equatorial instrument:* makers, ALVAN CLARK & SONS; aperture of objective, 5 inches (nearly completed).

(*g*) *Clock:* mean time; makers, PARKINSON & FRODSHAM.

DUBUQUE, *Iowa.*

Dubuque Observatory.

Longitude from Washington, 54m 27s.61 W.

Latitude, 42° 29′ 38″ N.

Authority for latitude and longitude: Boundary line between the States of Illinois and Wisconsin, projected through the city of Dubuque; and telegraphic record of star transits at Ann Arbor and Dubuque.

Director: ASA HORR, M. D.—Under the supervision of Prof. J. C. WATSON, in 1865.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* maker, WM. WÜRDEMANN, Washington, D. C. Aperture, 1½ inches; magnifying power sufficient to note time by stars of the 10th magnitude. Finding circle, 4½ inches diameter, reading by verniers and lenses to half a minute of arc. The pier extends 17 feet into the ground, through clay to gravel; it is 7 feet 6 inches diameter at base, 3 feet at top, which is 4 feet above the surface; is surrounded by a brick wall, 8 inches from the stone shaft, the space between (at the surface of the ground) being stuffed with oakum. The Y's rest on thin brass supports on the top of *stone pillars*, instead of the iron frame which acme with the instrument.

(*g*) *Clock:* mean time; makers, HOWARD & Co., Boston. Tower clock, reliable to less than a second a day through all extremes of temperature.

(*h*) *Chronometer:* mean time; maker, K. ZIMMERMAN, Liverpool, England.

Work: The transit instrument was erected, and has been used almost exclusively for the determination of local time.

ELIZABETH, *Union County, New Jersey.*

Observatory.

Longitude from Washington, $11^m\ 22^s.2$ E.
Latitude, 40° 40′ 19″ N.
Authority for latitude and longitude: United States Coast Survey.
Director: CHARLES W. PLYER.

INSTRUMENTS:

(*b*) ***Meridian transit instrument:*** makers, JOHN BLISS & SONS, New York; aperture, 1 inch; magnifying power, 10 diameters.

(*c*) ***Equatorial instrument:*** maker, HENRY G. FITZ; aperture of objective, 6¼ inches. Nine eye-pieces, from 50 to 630.

FORDHAM, *New York.*

Private Observatory.

Longitude from Washington, $12^m\ 40^s.47$ E.
Latitude, 40° 52′ 31″.3 N.
Latitude and longitude deduced from Coast Survey map of 1863 and American Ephemeris 1879, assuming the latitude and longitude of New York, given in the Ephemeris, to be the latitude and longitude of the City Hall.
Director: WILLIAM MEIKLEHAM.

INSTRUMENTS:

(*c*) ***Equatorial instrument:*** maker, JOHN BYRNE, of New York; aperture of objective, $4\frac{3}{10}$ inches; focal distance, 65 inches; magnifying powers of eye-pieces, 20, 30, 45, 60, 80, 150, 250, 300, 350, and 450; also an amplifier which doubles each of these powers when used. Attached to the telescope is a finder of 1½ inches aperture, magnifying 20 diameters. Right ascension circle divided to read to 4 seconds of time; declination circle divided to read to 1′ of arc. Both circles divided on silver and read by microscropes attached thereto. Driving-clock.

(*d*) ***Spectroscope:*** one.

(*g*) ***Clock:*** mean time; maker, SETH THOMAS, SONS & CO.

(*i*) ***Miscellaneous:*** Filar micrometer; divided on silver to measure $\frac{3}{10}$″ of arc in distance, and 6′ in position, with suitable eye-pieces and illuminating apparatus.

FORT DODGE, *Webster County, Iowa.*

Longitude from Washington, $1^h\ 8^m.5$ W.
Latitude, 42° 30′ N.
Authority for latitude and longitude: F. HESS.

Director: F. HESS.
Assistant: Mrs. P. B. HESS.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* makers, J. BROWN & SON, New York; aperture, 1 inch; magnifying power, 10½ diameters, with horizontal and vertical circle, each reading to 1.

(*c*) *Equatorial instrument:* aperture of objective, 2⅝ inches; for observations of the sun, aperture employed, 2⅝ inches; magnifying power ordinarily employed, 50 diameters.

(*g*) *Clock:* mean time; maker, G. M. WHEELER, Elgin, Ill.

(*i*) *Miscellaneous:* one TROUGHTON sextant and artificial horizon.

OBSERVATIONS DURING THE PAST YEAR (from January 1, 1880, to January 1, 1881):

No change in the personnel nor addition to the scant equipment of this station, which can hardly be called an observatory, has been made since last report.

Sun-spot observations have been continued throughout the past year, and many spots have been recorded. The new variable star τ *Cephei* has been observed a few times, and the space between β *Polaris* and ϵ *Cassiopeiæ* was frequently searched for other variables. In the course of hap-hazard searches for comets, two nebulæ were found, which may possibly be variable, since they are not given on charts and lists containing much fainter ones not visible at all with my highest magnifying power of 50 times. One of these nebulæ is located in approximate R. A. 21^h 21^m Dec. + 11° 50′, the other in R. A. 16^h 15^m Dec. — 1° 22′, as estimated by the eye (unaided by position circles) from neighboring stars.

Preparations had been made to observe the occultation of the planet Mars occurring here in the afternoon of March 17, but that day having been cloudy here, the observation could not be made. On the 10th of March at 4^h 20^m p. m., after having found that planet with his small transit, and knowing its exact position, viz: Az. S. 60° E., Alt. 57° 18′, the director, his wife, and two of his children could distinctly see it with the naked eye in broad daylight.

Many meteors and several extensive zodiacal lights and two very fine auroral displays have been recorded.

During December, 1880, and January, 1881, many extraordinary parheliæ and lunar halos, and on several occasions similar phenomena produced by the planet Venus, also have been observed here.

Nothing beyond short notices in our local newspapers and an occasional article in the Fort Dodge Messenger on current astronomical events of general interest has been published by me during the past year.

The work laid out for the present year consists in a continuation of the former miscellaneous observations and the special observations of the local times of the following phenomena:

1. Beginning of the partial eclipse of the sun, May 27, 1881.
2. The various phases of the total eclipse of the moon, June 11, in-

cluding the occultations of *b* Ophiuchi by the partially-eclipsed moon, and of c^2 Ophiuchi by the totally-eclipsed moon.

3. The first and second contacts at ingress of the transit of Mercury, November 7.

4. Close approaches of planets to prominent stars.

GEORGETOWN, *District of Columbia.*

Observatory of Georgetown College.

Longitude from Washington, $6^s.2$ W.
Latitude, 38° 54′ 26″.2 N.
Director: ——— (?)

GLASGOW, *Howard County, Missouri.*

Morrison Observatory.

Longitude from Washington, $1^h\ 3^m\ 5^s.93$ W.
Latitude, 39° 16′ 16″.75 N.

Authority for latitude and longitude: Longitude, exchange of clock signals with the Naval Observatory in June and July last, 5 nights. Latitude, from circumpolar stars observed on meridian circle.

Director: C. W. PRITCHETT.
Assistants: 1. H. S. PRITCHETT, *in charge of meridian circle.*
2. C. W. PRITCHETT, jr.

INSTRUMENTS:

(*a*) *Meridian circle:* one; makers, TROUGHTON & SIMMS; diameter of circles, 24 inches; divided to 5′; read by 4 microscopes to 1″; aperture of objective, 6 inches; for observations of the sun, aperture employed, 4 inches; magnifying power ordinarily employed, 200 diameters.

(*c*) *Equatorial instrument:* makers, ALVAN CLARK & SONS; aperture of objective, 12¼ inches; magnifying powers of eye-pieces, 50 to 1200.

(*f*) *Chronograph:* one.

(*g*) *Clock:* sidereal; maker, CHARLES FRODSHAM, London.

(*h*) *Chronometer:* sidereal; maker, T. S. & J. D. NEGUS, New York.

(*i*) *Miscellaneous:* Alt-azimuth, by L. P. CASELLA, London; comet-seeker, by ALVAN CLARK & SONS.

OBSERVATIONS DURING THE PAST YEAR (from January 1, 1880, to January 1, 1881):

(*a*) Observations for time; comparison stars; systematic work deferred for a time.

(*c*) (*c′*) Observations of double stars; micrometric measures of pairs specially needing observations; observations of planets and comets.

(*i*) Meteorological observations made three times each day. A time-ball is dropped daily at Kansas City, 105 miles west of the observatory, at mean noon of Kansas City. Clock signals are also sent to the Union Depot, Kansas City, daily at 4 p. m.

WORK PROPOSED FOR THE COMING YEAR (1881):

1. Continuation of the double-star measures.
2. Continuation of the observations of planets and comets.
3. Such meridian work as our time may allow and our wants may require.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY:

C. W. PRITCHETT: Red spot on Jupiter; published in Monthly Notices.

C. W. PRITCHETT: Method of observation of red spot on Jupiter; published in Astr. Nach.

H. S. PRITCHETT: Discussion of measures of diameters of Mars; published in Astr. Nach.

H. S. PRITCHETT: Discussion of observation on red spot on Jupiter; published in Proc. Am. Assoc.

H. S. PRITCHETT: Observations comet (*d*); published in Astr. Nach.

H. S. PRITCHETT: Observations comet (*e*); published in Astr. Nach.

HANOVER, *Grafton County, New Hampshire.*

Shattuck Observatory.

Longitude from Washington, $19^m\ 3^s.56$ E.

Latitude, 43° 42′ 15″.2 N.

Authority for latitude and longitude, Prof. C. A. YOUNG.

Directors: C. A. YOUNG, 1853;
CHARLES F. EMERSON, A. M., 1878.

Assistants: 1. GEORGE OTIS MITCHELL;
2. DANA CHASE BARBER;
3. SIDNEY BATES CADY.

Founded in 1853, through the liberality of G. SHATTUCK. Consists of a west rotunda and three additions. It has double brick walls and an air-chamber with a space of six inches ($0^m.15$) between the walls.

INSTRUMENTS:

(*a*) *Meridian circle:* makers, TROUGHTON & SIMMS; diameter of circle, 30 inches; divided to 5′; read by reading microscopes to 1′, and micrometers to single seconds; aperture of objective, 4 inches; magnifying power ordinarily employed, 120 diameters.

(*c*) *Equatorial instrument:* makers, ALVAN CLARK & SONS; aperture of objective, 9.25 inches; magnifying powers of eye-pieces, 100 to 1200, 20 in number.

(*d*) *Spectroscopes:* large 9-prism CLARK spectroscope; seven prism, double acting (equivalent to 13 prisms), fitting equatorial mentioned above.

(*f*) *Chronograph:* BOND'S spring governor.

(*g*) *Clocks:* one mean time; makers, UTZSCHNEIDER & FRAUENHOFER, connected with chronograph: one sidereal; makers, UTZSCHNEIDER & MAHLER, of Munich, connected with chronograph.

(*i*) *Miscellaneous:* Comet seeker, aperture 3.6 inches, mounted on large tripod; small portable telescope, aperture 3 inches; zenith sector, loaned by Coast Survey, aperture 4 inches; full set of common meteorological apparatus, including a recording barometer; sextant by HARDY, of London.

OBSERVATIONS DURING THE PAST YEAR:

(*a*) For time and latitude.

(*d*) Class illustration on reversal of lines, and for prominences.

(*i*) Meteorological observations 3 times per day; sun-spot observations since September 1, 1879.

WORK PROPOSED FOR THE COMING YEAR (1881):

Similar work, with special attention to sun spots, prominence, &c., and spectroscopic observations.

HASTINGS, *Westchester County, New York.*

Private Observatory.

Longitude from Washington, $12^{m}\ 42^{s}.7$ E.

Latitude, 40° 59′ 25″ N.

Authority for latitude and longitude: Coast Survey.

Director: HENRY DRAPER.

Assistant: A. HOFBAUER.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* makers, STACKPOLE & BROTHER; aperture, 2 inches; magnifying power, 45 diameters.

(*c*) *Equatorial instruments:* one reflector, 28 inches aperture, made by HENRY DRAPER; (*c′*) one refractor, 11 inches aperture, by ALVAN CLARK & SONS, with photographic corrector.

(*d*) *Spectroscopes:* 1 diffraction, 1 stellar photographic, 1 automatic, &c.

(*f*) *Chronograph:* one made by HENRY DRAPER.

(*g*) *Clock:* one mean time; maker, HOWARD.

(*h*) *Chronometers:* one mean time; maker, NEGUS: one sidereal; maker, NEGUS,

(*i*) *Miscellaneous:* Altitude and azimuth reflector of 15½ inches aperture.

OBSERVATIONS DURING THE PAST YEAR (from January to December):

(*c*) Stellar spectrum photographs, with 28-inch reflector of *α Lyræ*, *α Aquilæ*, *α Bootis*, *α Scorpionis*, *Capella*, Jupiter, Mars, &c.

(*c*) (*c′*) Photographs of the nebula in Orion, with 11-inch photographic telescope, the first ever taken, and requiring an exposure of 51 minutes.

WORK PROPOSED FOR THE COMING YEAR (1881):

Continuation of the above, with a series of experiments in physics as bearing on astronomy, in the new astro-physical laboratory in New York; the latter experiments especially directed to the presence of the non-metals in the sun The town laboratory is furnished with a siderostat with 9½-inch mirror, a gas engine of 4-horse power, 4 dynamo-electric machines, induction coils and spectroscopes, &c., suitable for the research.

HAVERFORD COLLEGE, *Montgomery County, Pennsylvania.*

Haverford College Observatory.

Longitude from Washington, $6^m\ 59^s.33$ E.
Latitude, 40° 0′ 36″.5 N.
(Triangulations from United States Coast Survey stations give:
Longitude, 5^h 1′ 11″.62; latitude, 40° 1′ 49″.73.)
Director: ISAAC SHARPLESS.
Assistant: WILLIAM BISHOP.

INSTRUMENTS:

(*a*) *Meridian circle:* one; diameter of circles, 26 inches; divided to 15′; read by 4 microscopes to 2″; aperture of objective, 4 inches

(*c*) *Equatorial instrument:* makers, HENRY FITZ, re-worked by CLARK; aperture of objective, 8¼ inches; magnifying powers of eye-pieces, 60 to 800.

(*f*) *Chronograph:* BOND'S magnetic.

(*g*) *Clocks:* one sidereal; maker, LUKENS: one sidereal; maker, HARPER; mercurial compensation.

(*i*) *Zenith instrument:* aperture, 2¼ inches: rejuvenated by FAUTH & Co., and to be set up as soon as addition is built to observatory, to determine our latitude.

OBSERVATIONS DURING THE PAST YEAR (from 9 mo., 1st, 1880, to 3 mo., 1st, 1881):

(*a*) Time observations.

(*c*) (*c′*) Phenomena of Jupiter's satellites; occultations by moon; double-star measures.

WORK PROPOSED FOR THE COMING YEAR (1881–'82):

Continuation of the above.

HUDSON, *Summit County, Ohio.*

Hudson Observatory.

Longitude from Washington, 17^m 32^s.06 W.

Latitude, 41° 14′ 42″.6 N.

Authority for latitude and longitude: Professor **ELIAS LOOMIS**, LL. D.

Director, **CHARLES J. SMITH.**

INSTRUMENTS:

(*a*) *Meridian circle:* one; maker, SIMMS, of London; diameter of circles, 18 inches; divided to 5′; read by 3 microscopes to 1″; aperture of objective, 3 inches.

Equatorial instrument: one; maker, SIMMS; aperture of objective, 4 inches; magnifying powers of eye-pieces, 50, 100, 150, 250, 350.

Clock: sidereal; maker, MOLINEUX; mercurial pendulum.

OBSERVATIONS DURING THE PAST YEAR:

No systematic course of observations pursued. Instruments used only for purposes of instruction.

IOWA CITY, *Johnson County, Iowa.*

Private Observatory.

Longitude from Washington, 57^m 52^s W.

Latitude, 41° 39′.8 N.

Authority for latitude and longitude: Observations made at the observatory during the past eleven years.

Director: **C. W. IRISH.**

Assistants: Mrs. C. W. IRISH;
Miss LIZZIE IRISH;
Miss RUTH IRISH;
Dr. C. M. HOBBY.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* a small one made by the director himself; aperture, one inch; magnifying power, 11 diameters.

(*c*) *Equatorial instrument:* maker, CHEVALIER, Paris; aperture of objective, 4 inches; magnifying powers of eye-pieces, 25 to 300.

(*f*) *Chronograph:* a Morse register.

(*g*) *Clock:* one mean time; beating three-quarter seconds: of German make.

WORK PROPOSED:

Observation of the coming transit of Mercury, if business occupations permit.

LAWRENCE, *Douglas County*, *Kansas*.

Observatory connected with Kansas State University.

Longitude from Washington, $1^h\ 12^m\ 47^s.9$ W.
Latitude, 38° 57′ 15″ N.
Authority for latitude and longitude: **FRED. W. BARDWELL**, late professor of astronomy, Kansas State University.
Director: H. S. S. SMITH.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* makers, STACKPOLE BROS.; aperture, 2¼ inches.

(*g*) *Clocks:* one mean time; makers, E. HOWARD & CO., Boston (medium): one sidereal; maker, BROCKBANKS, London (old).

(*h*) *Chronometer:* sidereal; makers, T. S. & J. D. NEGUS, New York (good).

(*i*) *Miscellaneous:* Sextant, by GAMBEY; comet-seeker, 6-inch object glass.

OBSERVATIONS DURING THE PAST YEAR:

(*b*) (*b′*) Time.
(*i*) Instruction.

WORK PROPOSED FOR THE COMING YEAR (1881):

Time observations and instruction.

LINWOOD, *Hamilton County*, *Ohio*.

Private Observatory.

Longitude from Washington, ——— ?
Latitude, ——— ?
Situated about one mile E. by S. from Cincinnati Observatory.
Director: R. H. MCCLURE.

INSTRUMENTS:

(*c*) One equatorial silvered glass Newtonian reflector. Diameter of the concave reflecting objective, 5½ inches; magnifying powers of the eye-pieces, 60, 100, and 200 diameters. The mirror, tube, and mounting all constructed by Mr. MCCLURE himself.

OBSERVATIONS DURING THE PAST YEAR (from February 8 to November 30, 1880):

(*c*) Sun-spots, Faculæ, Jupiter, Saturn, &c. Special attention given to Jupiter, of which a few rough sketches were made.

WORK PROPOSED FOR THE COMING YEAR (1881):

Same as above; will also observe the transit of Mercury. Will attempt to make a mirror of larger aperture, if the time can be spared from regular avocations.

MADISON, *Dane County, Wisconsin.*

The Washburn Observatory.

Longitude from Washington, $49^{m}\ 25^{s}.8$ W.

Latitude, 43° 4′ 36″.7 N.

Authority for latitude and longitude: A pier of the United States Coast and Geodetic Survey, about 500 feet from the observatory, has been connected by a triangulation with the transit-room, and the position given refers to the center of the transit circle.

Director: EDWARD S. HOLDEN.

Assistants: S. W. BURNHAM;
G. C. COMSTOCK;
F. W. WINKLEY.

The main Observatory consists of a dome for the equatorial, which is mounted, of a transit-room now ready for the REPSOLD circle, and of a director's room. A library and additional rooms are now building, as an east wing to the main building. A small student's observatory, built by Professor WATSON, contains a transit room for the Fauth transit, and a dome large enough for an 8-inch equatorial. The WATSON Solar Observatory is still unfinished. The building will probably be finished during the year.

INSTRUMENTS:

The following will be ordered in 1881:

(*a*) *A meridian circle:* maker, REPSOLD & BROTHER, Hamburg; diameter of circles, about 30 inches; divided to 2′; read by 4 microscopes to 1″. Aperture of objective, 4.8 inches; for observations of the sun, aperture employed, — inches; magnifying power ordinarily employed, — diameters.

The following instruments have been ordered:

(*b*) *Meridian transit instrument:* makers, FAUTH & CO., Washington; aperture, 3 inches; magnifying power, 60 and 120 diameters. This will have two 12-inch circles divided on the edges: one circle to 10″, the other for setting only. The fine circle has a level for latitude.

(*c*) *Equatorial instrument:* makers, ALVAN CLARK & SONS; aperture of objective, 15.5 inches; magnifying powers of eye-pieces, 145 to 1200.

(*f*) *Chronograph:* a chronograph by FAUTH & CO., with a conical pendulum, is provided.

(*g*) *Clocks:* one mean time; makers, SETH THOMAS CLOCK COMPANY: one sidereal; maker, HOHWU, of Amsterdam.

(*h*) *Chronometers:* one sidereal, maker, BLISS, No. 2786; one sidereal break-circuit, BLISS, No. 2791.

OBSERVATIONS DURING THE PAST YEAR (from January, 1880, to January, 1881):

(*c*) A coast survey transit (since removed) was used in the prime vertical on one night by Mr. COMSTOCK, and the latitude of a pier 40 feet north of the transit circle piers was found to be + 43° 4′ 37″.77 ± 0″.61.

WORK PROPOSED FOR THE COMING YEAR (1881):

The equatorial, with Messrs. HOLDEN & BURNHAM as observers, will begin a series of zone observations on the plan of HERSCHEL'S sweeps. The 3-inch transit will be used by Mr. COMSTOCK for time observations, and Polaris and the Sun will be observed at every culmination with time stars.

ADDITIONAL INFORMATION:

It is hoped to commence the printing of the publications of the Washburn Observatory during the year. No. 1 will be a description of the Observatory and its history up to January 1, 1881, together with the Reduction Tables prepared by the late director, Professor WATSON. No. II will contain Burnham's General Catalogue of Double Stars. No. I of the *Contributions* has already been printed, and contains a list of new nebulæ and double stars.

MOUNT HAMILTON, *Santa Clara County, California.*

Lick Astronomical Department of the University of California.

Longitude from Washington, $2^h\ 58^m\ 14^s.6$ W.
Latitude, 37° 21′ 3″ N.
Director: Not yet appointed.

INSTRUMENTS:

In process of construction.

WORK PROPOSED FOR THE COMING YEAR (1881):

Erection of small Observatory to accommodate the DRAPER 12-inch equatorial (CLARK & SONS) and time instruments (FAUTH). These are to be set up by Professors E. S. HOLDEN and S. W. BURNHAM in October, and used to observe the transit of Mercury.

ADDITIONAL INFORMATION:

From the report made to the trustees of the *James Lick Trust*, by Prof. S. W. BURNHAM, the following information is gathered respecting the situation and elevation of Mount Hamilton, upon which the Lick Observatory is to be erected:

"The city of San José, the nearest point of railroad connection from Mount Hamilton, is 50 miles south of San Francisco. Mount Hamilton, by the highway, is 26 miles from San José, nearly east, and is reached by a good road constructed two or three years since by the county of Santa Clara. In order to keep the grade within the limit of six feet in one hundred, the last portion of the road is carried up the ridges of the mountain by a circuitous route. The distance between the observatory and San José, in an air-line, is only 13 miles.

"The *approximate* geographical of the Observatory Peak is: Longitude, 121° 36′ 40″ W.; latitude, 37° 21′ 3″ N.

"The elevation of this point is 4,250 feet above the level of the sea. The north peak, which is about three-fourths of a mile distant, is 140 feet higher. There is a ridge between, along which is a good trail connecting the two peaks. The sides of the mountain, in most directions, are very steep, and form an acute angle at the summit. The view from the peaks is unobstructed in every direction, there being no higher ground within a radius of 100 miles. In this connection the report of Messrs. Herrmann Bros., the engineers who surveyed the road, will be of interest:

"'The scope of the horizon from Mount Hamilton takes in more ground, according to Professor Whitney's judgment, than almost any similar peak in the United States, there being no obstruction to the view from any quarter. It is remarkably free from fogs and clouds, as we had ample occasion to observe during our last winter's stay on the mountain when locating the road. The bearings of the most notable objects are as follows, the distances being taken, when out of our county, from our most reliable maps:

Mount Loma Prieta	S. 35° 5′ W.,	19½	miles.
Mount Thayer	S. 51° 18′ W.,	19¾	"
Mount Poucher	S. 38° 35′ W.,	6	"
Block Mountain	S. 87° W.,	27½	"
Mount Tamalpais	N. 51° 20′ W.,	66	"
Mission Peak	N. 47° 55′ W.,	16	"
Mount Story	N. 25° 45′ W.,	10¼	"
Mount Diablo	N. 21° 45′ W.,	39½	"
Mount Sautana	S. 37° ′ E.,	35	"
Murphy's Peak	S. 6° 5′ W.,	15	"

"'None of these points reach the altitude of Mount Hamilton. Of those within a radius of 20 miles the Loma Prieta reaches 3,800 feet; Thayer 3,550, and Block Mountain 2,800. All the rest are between 1,500 and 2,500 feet. Of the further peaks Mount Diablo is 3,856.'"

MOUNT LOOKOUT, *Hamilton County, Ohio.*

Cincinnati Observatory.

Longitude from Washington, 29ᵐ 29ˢ.33 W.

Latitude, 39° 8′ 20″ N.

Authority for longitude: Washington Observations for 1877, Appendix IV. For latitude: preliminary reduction of unpublished observations.

Directors: O. M. MITCHEL, 1842;
H. TWITCHEL, 1853;
W. DAVIS, 1854;
C. ABBE, 1859;
ORMOND STONE, 1875.
Assistant: HERBERT A. HOWE.
Students: H. V. EGBERT,
A. S. FLINT.

Founded in 1842 by a society established for the purpose. The ground was donated by NICHOLAS LONGWORTH. A new observatory was erected in 1870. It owns an equatorial by MERZ and MAHLER, with an aperture of 11.8 inches=0m.30.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* makers, BUFF and BERGER; aperture, 3 inches; magnifying power, 100 diameters.

(*c*) *Equatorial instruments:* one made by UTZSCHNEIDER and FRAUENHOFER; finished by MERZ & MAHLER; object-glass re-figured by ALVAN CLARK & SONS; aperture of objective, 11¼ inches; magnifying powers of eye-pieces, 90 to 1400. (*c'*) One by ALVAN CLARK & SONS; aperture, 4 inches; magnifying powers, 15 to 250.

(*f*) *Chronograph:* BOND.

(*g*) *Clocks:* two mean time; makers, ROBERT MOLYNEUX, JAMES RITCHIE & SON.

(*h*) *Chronometer:* sidereal; makers, WILLIAM BOND & SON.

(*i*) *Miscellaneous:* Magnetic theodolite; maker, GAMBEY. Sextant; makers, STACKPOLE & BROTHER. Inclinometer, time-ball, telegraphic apparatus, &c.

OBSERVATIONS DURING THE PAST YEAR (from September 1, 1879, to September 1, 1880):

(*b*) Determination of time and latitude.

(*c*) Micrometrical measurements of double stars. Observations of sun-spots. Determinations of positions of comets Hartwig and Pechüle. (*c'*) Approximate determinations of positions of stars south of 23° of south declination. (Continuation Argelander's Durchmusterung.)

WORK PROPOSED FOR THE COMING YEAR (1881):

Continuation of Durchmusterung south of 23° of south declination.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR 1880:

ORMOND STONE: Micrometrical measurements of 1,054 double stars, vol. v, Publications of Cincinnati Observatory.

NASHVILLE, *Davidson County, Tennessee.*

Private Observatory.

Longitude from Washington, $38^m\ 56^s$ W.
Latitude, 36° 10′ 01″ N.

Authority for latitude and longitude, United States Coast Survey.

Director: E. E. BARNARD.

INSTRUMENTS:

(*c*) *Equatorial instrument:* a simple equatorial; aperture of objective, 5 inches; magnifying powers of eye-pieces, 52 to 520. (*c′*) A small 2½ inches alt-azimuth telescope with good rack-work; all the eye-pieces of large telescope fit it.

(*i*) *Miscellaneous:* In use also a small instrument. The base of this instrument is divided to degrees and read by vernier to 3′ of arc. An upright pillar carries a semi-circle of altitude; this is divided to degrees and read to 3′ of arc by a vernier. Attached to the semi-circle of altitude is an hour-circle divided to 4^m of time and read to single minutes by vernier. Upon the hour-circle rests a semi-circle of declination divided to degrees and read to 3′ of arc by vernier. On the base are two levels, the instrument being leveled by three adjusting screws, which also serve as feet. The declination semi-circle carries a very small telescope about .4 inch diameter of objective. The telescope has a diagonal eye-piece with metal reflector and single lenses and vertical and horizontal hairs. The instrument was made by W. & S. Jones, London. It is used for identifying stars in comet observations by setting the altitude semi-circle for the latitude, thereby converting the instrument into an equatorial.

OBSERVATIONS DURING THE PAST YEAR:

(*c*) (*c′*) Observations of the planets and comets.

WORK PROPOSED FOR THE COMING YEAR:

Continuation of the work of last year.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR:

The only publications have been: Letters to the English Mechanic (London), Science (of New York), &c.

ADDITIONAL INFORMATION:

Observations have been from June, 1880, to January, 1881. These observations have consisted chiefly in watching the changes on Jupiter; getting positions of comets, and making drawings of Saturn. From July 11 to January 7 about fifty transits of the great red spot on Jupiter recorded and some seventy-five sketches and drawings made of the configuration of his surface. Transits of a number of spots, &c., on Jupiter also observed. One black transit of Satellite III and four dark (brownish) transits of Satellite I also noted.

A very good set of drawings made of the remarkable black spots which broke out just north of Jupiter's great equatorial band, in the latter part of October (1880). These drawings show the remarkable transformations of these spots until their finally encircling the planet with a beautiful scolloped belt.

The comets of which positions have been obtained are Swift's (the first position of this comet on October 21), and Pechüle's.

NEW HAVEN, *New Haven County, Connecticut.*

Winchester Observatory of Yale College.

Longitude from Washington, 0h 16m 30s.1 E.

Latitude, 41° 18′ 36″.5 N.

Authority for latitude: Zenith-telescope observations in 1857–'58. See Am. Jour. of Sci., vol. 30, p. 52. Second series. (Coast Survey latitude 41° 18′ 40″.67.)

Authority for longitude: United States Coast Survey.

President of board of managers: C. S. LYMAN.

Astronomer in charge of horological bureau: Dr. LEONARD WALDO.

Assistant astronomer: WILLIAM BEEBEE.

Founded in 1830. Several instruments were presented by Messrs. SHELDON and W. HILLHOUSE.

Directors: E. LOOMIS, 1831;
D. OLMSTEAD, 1836;
C. S. LYMAN, 1847.

INSTRUMENTS:

(*a*) *Meridian circle:* makers, ERTEL & SONS, 1845. Formerly the property of the U. S. Naval Observatory. Altered by WILLIAM J. YOUNG, 1855, and regraduated 1876. Diameter of circles, 40 inches; divided to 2′; read by six microscopes to 1″; aperture of objective, 3.8 inches; for observations of the sun, aperture employed, 1.7 inches; magnifying power ordinarily employed, 190 diameters; focal length, 58.2 inches.

(*b*) *Meridian transit instruments:* one made by C. S. LYMAN, of 36-inch focal length; aperture, 2.6 inches; magnifying power, 185 diameters. Circle, 12 inches, reading to 10″ by verniers; it has declination micrometer and fine level, for use as zenith telescope, made in 1852–'53: one by TROUGHTON & SIMMS, London; aperture, 3.99 inches; magnifying power, 150–200 diameters; focal length, 5.108 feet. (*b′*) Combined transit and zenith telescope, of 36-inch focal length; aperture, 2.6 inches; power, 185 diameters; 12-inch circle, reading to 10″ by verniers; declination micrometer and sensitive level for latitude work; made in 1852–'56: object-glass by FITZ, design and mounting by C. S. LYMAN.

(*c*) *Equatorial instruments:* makers, ALVAN CLARK & SONS; aperture of objective, 9 inches; magnifying powers of eye-pieces, 40, 80, 140, 200, 280, 450, 620. (*c′*) Portable 4⅔-inch refractor by Messrs. CLARK & SONS.

(*d*) *Spectroscope:* by A. CLARK & SONS, of 7 prisms twice traversed.

(*f*) *Chronographs:* one by A. CLARK & SONS, with conical pendulum governor; another by WILLIAM BOND & SON, Boston, with BOND'S spring governor.

(*g*) *Clocks:* one mean time; made by E. HOWARD & CO., Boston; one by WILLIAM HILLHOUSE, New Haven: one sidereal; by WILLIAM BOND & SON, Boston; one by APPLETON, London; one by E. HOWARD & CO.

(*h*) *Chronometers:* one pocket chronometer, mean time; by JOHNSON, London: one sidereal; by POOLE, London, improved by NEGUS, New York.

(*i*) *Miscellaneous:* Two bifilar position-micrometers, one by DOLLOND, the other by FAUTH & CO., Washington, D. C.; a patent sextant and a patent reflecting circle, by PISTOR & MARTINS, Berlin; repeating relays, sounders, &c., for time service. Yale College has also in use a 5-inch 10-foot refractor by DOLLOND; a sidereal clock and a 20-inch transit instrument, in charge of Professor LOOMIS.

The horological bureau is a department of the Winchester Observatory, organized in January, 1880, with a special equipment of instruments for a regular and extended public time service. The standard time, by law of the State, is that of the meridian of the city hall, New York, which is $4^m\ 19^s.6$ slow of New Haven, and $12^m\ 10^s.5$ fast of Washington. Another important work of the bureau is the testing of watches and chronometers in the interest of the watch manufacture, for which hot and cold closets and other special facilities are provided.

There is also connected with the Observatory a thermometrical bureau, in charge of Dr. WALDO, for the verification of clinical and other thermometers. It is amply furnished with the best standards, apparatus of comparison, and other facilities for this work. About 1,000 thermometers have been tested in the last six months.

A. REPSOLD & SONS, of Hamburg, are constructing for the Observatory a heliometer of 6 inches aperture and embodying the latest improvements. It is to be finished during the year 1881.

OBSERVATIONS DURING THE PAST YEAR (1880):

(*a*) Besides the regular time-service and the thermometric work, a series of observations has been made, with interchange of the observers, for determining telegraphically the difference of longitude between Cambridge and New Haven, the observers being Prof. WILLIAM A. ROGERS, of Cambridge, and Dr. WALDO, of New Haven.

WORK PROPOSED FOR THE COMING YEAR (1881–'82):

The regular time and thermometric service, and the erection of a building for the heliometer, with preparation for observing the approaching transit of Venus, and for other work with this instrument.

NEWINGTON, *Hartford County*, *Connecticut.*

Private Observatory.

Longitude from Washington, $21^m\ 25^s$ E.

Latitude, 41° 44′ 0″ N.

Authority for latitude and longitude: Difference from Hartford Statehouse, Coast Survey.

Director: D. W. EDGECOMB.

INSTRUMENTS:

(*c*) *Equatorial instrument:* Makers, A. CLARK & SONS; aperture of objective, 9.4 inches; magnifying powers of eye-pieces, various up to 2,000.

(*g*) *Clock:* Mean time; Swiss regulator, seconds.

VI. ADDITIONAL INFORMATION:

This Observatory consists of a small frame building, with dome 12 feet 6 inches diameter, upon the grounds of the owner, covering an equatorial telescope. The latter rests upon a granite pedestal, weighing about 1,500 pounds. The mounting is by YOUNG, of Philadelphia, and is of the best workmanship. The declination circle is 13 inches in diameter, reading by verniers to 10 seconds of arc. The hour circle is 10 inches diameter, reading by verniers to 4 seconds of time. The graduations are upon silver. The object-glass, tube, and finder are by A. CLARK & SONS. The aperture of the object-glass is 9.4 inches, with a focal length of 121 inches, and is without doubt the finest specimen of the skill of Mr. ALVAN CLARK. Under the most rigid tests, its figure is found to approach very closely to absolute perfection. It is shown also by the vision it gives of the closest double stars and the faintest companions to bright stars hitherto discovered. Among the former, γ^2 *Andromedæ*, λ *Cassiopeæ*, and η *Coronæ* in its present position may be mentioned, and of the latter class, the companions to γ *Lyræ*, ζ *Aquillæ*, ε and ρ *Hydræ*, the star closely following the attendant to *Regulus*, and under very favorable circumstances the 2″ companion to ε *Coronæ*. The instrument has been used for general observations of the stars, moon, and planets, other occupations preventing the owner from carrying on at present any more regular work.

NEW WINDSOR, *Mercer County, Illinois.*

Observatory.

Longitude from Washington, $53^m\ 40^s$ W., approximately.

Latitude, 41° 13′ N., approximately.

Authorities for latitude and longitude: Director's own observation, and from longitude of government arsenal at Rock Island, Ill.

Director: EDGAR L. LARKIN.

Permanent Observatory, brick pier, and revolving dome.

INSTRUMENTS:

(*c*) *Equatorial instrument:* makers, ALVAN CLARK & SONS; aperture of objective, 6 inches; magnifying powers of eye-pieces, 27, 60, 130, 250, 300, 600, with prism and solar eye-piece. Two of the eye-pieces are GUNDLACH'S periscopic.

(*g*) *Clock:* sidereal; ordinary clock.

(*i*) *Miscellaneous:* Planisphere, charts, maps, and catalogues.

OBSERVATIONS DURING THE PAST YEAR (from January 5, 1880, when telescope was mounted, to February 23, 1881):

(*c*) With high powers, doubles and variables; also observations on planets and on the sun, daily.

WORK PROPOSED FOR THE COMING YEAR (1881):

Variables, and comet seeking; also, searching for nebulæ.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR:

EDGAR L. LARKIN: Motion. Published in Kansas City Review, vol. iv, p. 177.

EDGAR L. LARKIN: Meteor Notes. Published in Science Observer, Boston, No. 28, p. 27.

Current newspaper articles.

NEW YORK, *New York.*

Columbia College Observatory.

Longitude from Washington, 16^m 29^s.9 E.

Latitude, 41° 18′ 36″.5 N.

Director: ——?

NEW YORK, *New York.*

Private Observatory.

Longitude from Washington, 12^m 15^s.47 E.

Latitude, 40° 43′ 48″.53 N.

Authority for latitude and longitude: United States coast surveying party (1859), with zenith telescope upon 24 pairs of stars, and telegraphic communication with Washington and Cambridge.

Director: L. M. RUTHERFURD.

Assistant: D. C. CHAPMAN.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* maker, STACKPOLE; aperture 3 inches. Only used for time.

(*c*) *Equatorial instrument:* makers, Messrs. RUTHERFURD & FITZ; aperture of objective, 13 inches. The telescope has been employed mostly in photographing the sun, moon, and groups of stars.

(*f*) *Chronograph:* MORSE.

(*g*) *Clock:* sidereal; maker, DENT.

NORTHFIELD, *Rice County*, *Minnesota.*

Carleton College Astronomical Observatory.

Longitude from Washington, $1^h\ 4^m\ 23^s.85$ W.

Latitude, 44° 27′ 40″.77 N.

Authority for latitude: zenith telescope observations of 40 pairs of stars reduced to apparent places from Safford's catalogue.

Longitude depends on exchange of telegraphic signals between Coast Survey Office at Saint Paul and director at Northfield.

Director: WILLIAM W. PAYNE.

Assistant: C. W. BEERS.

Completed in 1878. Attached to Carleton College central building, 6 meters long, surmounted by a dome, with two wings, one used for meridian instruments, the other for the library.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* makers, Messrs. FAUTH & CO.; aperture, 3 inches; magnifying powers, 60, 70, and 80 diameters.

(*c*) *Equatorial instruments:* makers, Messrs. A. CLARK & SONS; aperture of objective, 8¼ inches; magnifying powers of eye-pieces, 50, 100, 200, 400, 800. (*c′*) Portable equatorial: maker, JOHN BYRNE of New York; aperture of objective 4.3 inches.

(*f*) *Chronograph:* one, made by A. CLARK & SONS.

(*g*) *Clocks:* one mean time; makers, Messrs. E. HOWARD & CO., No. 196: one sidereal; makers, Messrs. E. HOWARD & CO., No. 195.

(*h*) *Chronometer:* sidereal; makers, Messrs. BOND & SONS, No. 374.

(*i*) *Miscellaneous:* The Observatory has been favored by the loan of a good zenith telescope for several months from Lieut. EDWARD MAGUIRE, chief engineer in the department, with headquarters at Saint Paul. The large equatorial is provided with micrometer, with a full battery of eyepieces.

OBSERVATIONS DURING THE PAST YEAR:

Class instructions and instrumental errors.

(*a*) Transit used for time observations. Railroad time is given at 12 o'clock, noon, to the Northwestern Telegraph Company for railroad companies of this and adjoining States.

(*b*) Our time signal daily goes over 1,285 miles of wire.

(*c*) (*c′*) Micrometrical measures of double stars. Positions of comets and asteroids.

(*c′*) Small equatorial devoted to class instruction entirely.

(*i*) Determination of latitude and longitude of the Observatory.

WORK PROPOSED FOR THE COMING YEAR (1881):

1. Time observations.
2. Other work essentially as given above.

ADDITIONAL INFORMATION:

Printed matter from the Observatory has consisted of articles for the daily papers of Saint Paul, Minneapolis, and Chicago. The Observatory having no funds for publication purposes, could do nothing in this way thus far.

(Near) OXFORD, *Lafayette County, Mississippi.*

Observatory of University of Mississippi.

Longitude from Washington, 49^m 55^s.03 W.
Latitude, 34° 22′ 12″.64 N.
Authority for latitude and longitude: R. B. FULTON.
Director: R. B. FULTON.
The Observatory was erected in 1876.

INSTRUMENTS:

(*a*) *Altitude-azimuth:* makers, LEREBOURS & SECRETAN; diameter of circles, 10 inches; divided to 10′; read by 4 microscopes to 10″; aperture of objective, 1½ inches.

(*b*) *Meridian transit instrument:* makers, B. PIKE & SONS; aperture, 2¼ inches.

(*c*) *Equatorial instrument:* maker, MERZ, of Munich; aperture of objective, 4½ inches; magnifying powers of eye-pieces, 96 to 312 diameters.

(*d*) *Spectroscope:* KIRCHOFF'S 4-prism table spectroscope.

(*g*) *Clock:* mean time; makers, RITCHIE & SONS, Boston.

(*h*) *Chronometer:* sidereal; makers, WILLIAM BOND & SON, Boston.

WORK PROPOSED FOR THE COMING YEAR (1881):

Determination of variation of magnetic needle in various places in this State.

PHELPS, *Ontario County, New York.*

Red House Observatory.

Longitude from Washington 12^s W.
Latitude, 42° 58′ N.
Director: WILLIAM R. BROOKS.
Assistant: Mrs. BROOKS.

INSTRUMENTS:

(*c*) A silvered-glass reflecting telescope of 5 inches aperture and 50 inches focal length, mounted as a Newtonian on alt-azimuth stand. A 2-inch reflector, 36 inches focus. Both made by the director.

(*g*) *Clock:* mean time; makers unknown; marine.

OBSERVATIONS DURING THE PAST YEAR (from January 1, 1880, to January 31, 1881):

(*a*) Sun-spots were observed with the 5-inch reflector on February 6, 8, 9, 22, 24; March 18 and 31; April 7, 12, and 28 (very large group);

May 1, 3, 11; September 12, largest group for many years, equal to ¼ of the sun's diameter; October 3, and December 4. Drawings were made of the most remarkable spots.

Hartwig's comet was observed on October 2, the evening of the day of announcement; also on October 3, 4, 5, 6, 7, 8, 9, and 10. On 3d instant it was in the same field with Alphecca. Swift's comet was observed November 5 and 26, December 4. Owing to dense clouds Pennule's or Pechüle's comet was not seen until December 31, when it was quickly picked up with 2-inch achromatic in R. A. 19^h 59^m N. Dec. 19° 23′. It was also seen January 1, 1881; January 2, 19, and 20.

Preparations were made to observe the occultation of Mars, March 17, but clouds prevented; also the partial eclipse of sun December 31, but observations were again frustrated by clouds.

WORK PROPOSED FOR THE COMING YEAR (1881):

Mainly comet seeking; solar phenomena and the planets will also receive attention.

ADDITIONAL INFORMATION:

Descriptive articles on HARTWIG'S, SWIFT'S, and PECHÜLE'S comets of 1880, also remarkable solar spots, have been published in one or more of the following papers: "Scientific American," "Science Observer," "Science," "Rochester Democrat and Chronicle," "Geneva Courier," "Phelps Citizen."

PHILADELPHIA, *Pennsylvania.*

Central High-School Observatory.

Longitude from Washington, 7^m $33^s.64$ E.
Latitude, 39° 57′ 7″.5 N.
Director: ———?

POUGHKEEPSIE, *Dutchess County, New York.*

Vassar College Observatory.

Longitude from Washington, 12^m $38^s.5$ E.
Latitude 41° 41′ 18″ N.
Director: MARIA MITCHELL.
Observatory built in 1878.

INSTRUMENTS:

(*a*) *Meridian circle:* maker, YOUNG, of Philadelphia; aperture of objective, 3¾ inches.

(*c*). *Equatorial instrument:* object-glass by CLARK; aperture of objective, 12⅓ inches; magnifying powers of eye-pieces, 200 to 600+.

(*f*) *Chronograph:* one.

(*g*) *Clock:* one, sidereal; makers, BOND & SON.

(*h*) *One chronometer:* mean time; makers, BLISS & CREIGHTON.

(*i*) *Miscellaneous:* Small telescopes; one by CLARK & SONS; aperture, 3 inches.

OBSERVATIONS DURING THE PAST YEAR (from 1880 to 1881):

(*a*) Observations for the time.

(*c*) Observations on Saturn.

(*i*) The sun is photographed on every fine day at noon.

WORK PROPOSED FOR THE COMING YEAR (1881):

(*a*) Observations for time.

(*c′*) Observations on planets, especially Saturn.

(*i*) Observations on sun-spots.

PRINCETON, *New Jersey.*

Observatories of the College of New Jersey.

Longitude from Washington, $9^m\ 34^s.54$ E.
Latitude, 40° 20′ 57″.8 N.
Director: C. A. YOUNG.

The HALSTED *Observatory*, which was built in 1870, but never equipped, is being put in order for the reception of the great equatorial of 23 inches in diameter. This magnificent instrument, which is provided for by the liberal subscriptions of friends of the college, is in process of construction by the CLARKS at Cambridgeport. The object-glass is completed, and is a very fine one; the mounting is well under way, and unless something unexpected occurs the instrument will be in position before JANUARY 1, 1882. The telescope will be occupied at first mainly with stellar spectroscopy; and a spectroscope is being constructed for it by HILGER, of London, under the kind supervision of Mr. CHRISTIE, of the Greenwich Observatory.

The *Observatory* of the JOHN C. GREEN SCHOOL OF SCIENCE, which was erected and provided with instruments in 1877, remains substantially unchanged. A new 3-inch transit, by FAUTH was mounted in the west room in 1879, and the AYCRIGG transit was transferred permanently to the prime vertical. A reflecting circle by PISTOR & MARTINS has also been added, and a full set of meteorological instruments.

The principal employment of this Observatory and of Professor YOUNG is in giving instruction in practical astronomy; a little scientific work has, however, been accomplished. During the winter of 1878–'79 a telegraphic connection with Washington was effected, and six nights' observations put the Princeton meridian circle $9^m\ 34^s.54 \pm 0^s.02$ east of the Observatory dome at Washington. During 1879 and 1880 five independent series of latitude determinations have been made by two different observers, Mr. M. McNeill and Mr. A. S. Flint, with three different instruments, the Kahler transit and the Fauth transit (used as zenith telescopes), and the prime vertical. The results agree remarkably well, all giving the latitude between 40° 20′ 57″.76 and 40° 20′ 57″. 81. The final result is 40° 20′ 57″.79 ± 0″. 04. In November, 1879, a series of micrometrical observations were made upon the planet Mars with the 9½-inch equatorial, for the purpose of fixing its polar compression. The reduction of the observations gives $\frac{1}{219}$ for the value of this quantity: a result surprisingly accordant with that deduced theoretically by Adams, on the supposition that the law of density of the planet is not very different from the earth's. Both satellites were readily seen with the instrument, and this fact, with many others, goes to show that the telescope, the object-glass of which it will be remembered has the Gaussian curves, is one of the best, if not the best, of its size in existence.

Occasional spectroscopic observations have been made; especially a minute examination of the 70 dark lines in the solar spectrum given by Ångstrom and Thalen as belonging to the spectra of two or more metals in common; indicating, according to Mr. Lockyer's ideas, the existence of some common constituent in the metals concerned, and so tending to show them to be really non-elementary. The examination was made in the summer of 1881 with an apparatus of unprecedented dispersive power, consisting of a Rutherfurd grating of 17,000 lines to the inch, and collimator and telescope of about 4 feet focus. As a result, 56 lines of the 70 were found to be distinctly double or multiple; 7 were doubtful, generally because they could not be certainly identified, and 7 appeared to be single; 3 of the 7, however, while shown on the *map* as common to iron and some other metal, are not so given in Thalen's tables. On the whole, it is clear that the facts brought out do not favor Lockyer's hypothesis.

One remarkable solar prominence was observed in October, 1881, which in an hour reached an elevation of 350,000 miles—the highest yet on record.

The spectra of several comets have been observed, and some series of observations have been made upon their places which have been of use in computing their orbits. A few double-star measures have been taken; and observations were made upon the transit of Mercury in 1878, the solar eclipse of last December, and sundry occultations.

The solar eclipse of 1878 was observed at Denver by an expedition sent out from Princeton, under the direction of Professors Brackett and Young, and its results were duly published in the American Journal of Science.

Besides the members of the college classes, several others have availed themselves, for a longer or shorter period, of the opportunities at Princeton for the study of practical astronomy.

PROVIDENCE, *Providence County, Rhode Island.*

Seagrave Observatory.

Longitude from Washington, $22^m\ 34^s.51$ E.

Latitude, 41° 49′ 46″.40 N.

Authority for latitude and longitude: United States Coast Survey and ourselves, F. E. SEAGRAVE and LEONARD WALDO.

Director: F. E. SEAGRAVE.

INSTRUMENTS:

(*c*) *Equatorial instrument:* one equatorial; makers, ALVAN CLARK & SONS; aperture of objective, 8¼ inches; magnifying powers of eye-pieces, 93, 121, 184, 311, 571; negatives, 518, 116, 230, 335, 375; positive eye-pieces achromatic, 248.

(*d*) *Spectroscope:* one by BROWNING, which consists of 4 whole and 2 half prisms of 60°; flint glass; gives a dispersive power of ten prisms by reflection.

Chronometer: sidereal; maker, VICTOR KULLBERG, London.

OBSERVATIONS DURING THE PAST YEAR (from June 20, 1880, to December 31, 1880):

1. Observations of 61 *Cygni* from June 20, 1880, to December 31, 1880, for the purpose of determining the amount of its proper motion.
2. Observations of a few of BURNHAM'S double stars.
3. A few observations of the position angles and distances of the satellites of Saturn.

WORK PROPOSED FOR THE COMING YEAR (1881):

It is proposed this year to select some star in the northern hemisphere (as near the pole as possible) that has a large proper motion, and select two or three smaller stars that are in the same field of vision, and measure the distance and position angles of them from the large star, for the purpose of determining the amount of proper motion, and possibly its parallax.

ADDITIONAL INFORMATION:

It is also intended to observe the satellites of Saturn during the next opposition, and measure the distances and position angles of the small stars next Mars during the opposition of December, 1881.

RIVERDALE, *New York County, New York.*

Longitude from Washington —

Latitude —

Not yet determined, owing to the recent removal of the Observatory from Fordham to Riverdale.

Director; WILLIAM MEIKLEHAM.

INSTRUMENTS:

(*c*) *Equatorial instrument:* maker, JOHN BYRNE, of New York; aperture of objective, $4\frac{3}{10}$ inches; focal distance, 65 inches; magnifying powers of eye-pieces, 20, 30, 45, 60, 80, 150, 250, 300, 350, and 450; also an amplifier, which doubles each of these powers when used. Attached to the telescope is a finder of $1\frac{1}{2}$ inches aperture, magnifying 20 diameters. Right ascension circle divided to read to 4 seconds of time; declination circle divided to read to 1′ of arc. Both circles divided on silver and read by microscopes attached thereto. Driving-clock.

(*d*) *Spectroscope:* one.

(*g*) *Clock:* mean time; maker, SETH THOMAS, SONS & CO.

(*i*) *Miscellaneous:* Filar micrometer; divided on silver to measure 0″.3 of arc in distance and 6′ in position, with suitable eye-pieces and illuminating apparatus.

OBSERVATIONS DURING THE PAST YEAR:

No observations have been systematically made during the year ending January 1, 1881, owing to the removal of the observatory and the consequent confusion arising therefrom.

ROCHESTER, *Monroe County, New York.*

Warner Observatory.

Longitude from Washington, $3^m\ 8^s$ W.
Latitude, 43° 8′ 17″ N.
Authority for latitude and longitude: Signal Service officer.
Director: LEWIS SWIFT.

INSTRUMENTS:

(*c*) *Equatorial instrument:* makers, ALVAN CLARK & SONS (constructing); aperture of objective, 16 inches; magnifying powers of eye-pieces, from 45 to 2000. (*c′*) Altitude-azimuth, $4\frac{1}{2}$ inches, by FITZ; powers from 25 to 432. Telescope $4\frac{1}{2}$-inch refractor, originally by FITZ, but since last report the flint lens of the objective was unfortunately broken; it has been replaced by ALVAN CLARK & SONS. Its performance, which was always good, appears to be rather better than before the accident.

OBSERVATIONS DURING THE PAST YEAR:

The work done during the past year has been a repetition of that for several years past, viz, comet seeking and observing those discovered by others. The nebulæ observed and heretofore overlooked, which, however, are very few in number, have been also carefully recorded on star charts. This facilitates the prompt detection of a comet. Much caution, however, is necessary not to announce and especially not to cable the discovery of a comet where no motion has been detected.

The year 1880, and thus far in 1881, have been remarkable as the most unfavorable for such work for many years past.

On October 10–11, about midnight, another new comet was discovered. Although no positive motion was detected in two hours' watching, from a strong suspicion that it was a comet, the discovery was telegraphed to four astronomers widely separated, in the hope that some one of them would be fortunate enough to have a clear sky, and be able to secure an early observation before the moon would interfere. Only one, Professor BOSS, of the Dudley Observatory, succeeded in finding it, and fortunately he obtained the first position of it that could be used in computing its orbit. On the evening of the 11th, as soon as twilight had disappeared and in presence of a half moon, it was re-observed and immediately cabled, but owing to moonlight it was not discovered in Europe until October 25. The comet though large, was very faint, and proved to be identical with comet III, 1869 (TEMPEL), which adds another to the list of periodic comets. It was for some time a question whether its period was 11 or 5½ years. A thorough discussion of all the observations during its present and last observed apparition by Prof. S. C. CHANDLER, jr., and also by others, proves beyond all doubt that its period is a little less than 5½ years.

The Warner Observatory is not yet completed, though work on it is progressing satisfactorily, and it will be ready for occupancy in early autumn. The telescope, a 16-inch refractor by the CLARKS, is nearly completed.

ADDITIONAL INFORMATION:

The Warner Observatory has issued the following circular:

TO AMERICAN ASTRONOMERS.

ROCHESTER, N. Y., *January* 5, 1881.

Learning that the Imperial Academy of Sciences of Vienna has withdrawn its offer of a gold medal valued at $60 for the discovery of comets, and being desirous that the search for them should not be abandoned, I hereby offer for every such discovery, subject to the conditions which follow, the sum of $200 in gold as a prize, to be known as the Warner Safe Remedy Prize.

CONDITION 1.—The comet must be unexpected and telescopic, excepting only the comet of 1812, which is expected to reappear during the coming year.

CONDITION 2.—The first discovery must be made in the United States or Canada.

CONDITION 3.—Immediate notification by telegraph must be made to Prof. Lewis Swift, of Rochester, director of the Warner Observatory, who will cause the same to be cabled to Europe, and will also send notification to astronomers in this country by special circular or associated press dispatches.

CONDITION 4.—The telegram must give the time of discovery, the position, direction, and daily rate of motion with sufficient exactness to enable at least one astronomer to find it.

CONDITION 5.—In the event of any dispute which may arise regarding priority of claim or non-conformity with the conditions named, the decision shall be referred to Prof. Asaph Hall, of the Naval Observatory, Washington, D. C., and Prof. C. A. Young, of Princeton Observatory, and their decision shall be final.

The above offer, unless previously renewed, will expire January 1, 1882.

H. H. WARNER.

SAINT LOUIS, *Missouri.*

Observatory of Washington University.

Longitude from Washington, $52^m\ 37^s.02$ W.

Latitude, 38° 38′ 3″.64 N.

Authority for latitude and longitude: A pier about 150 feet away from the observatory pier was located by HARKNESS and EIMBECK (1870). A survey was made from that pier to the new one.

Director: J. K. REES, 1877.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* maker, WÜRDEMANN; aperture, 2.65 inches; magnifying power, 90 diameters, with micrometer attachment.

(*c*) *Equatorial instrument:* maker, H. FITZ, of New York City; aperture of objective, 6¼ inches; magnifying powers of eye-pieces, 76, 125, 190, 305, and 456 diameters. (*c′*) *Finder:* $2\frac{3}{100}$ inches aperture; magnifying power, 23 diameters.

(*d*) *Spectroscope:* one single prism BROWNING spectroscope.

(*e*) *Photometer and other subsidiary apparatus:* filar position, micrometer attached; clock-work for moving telescope.

(*g*) *Clock:* mean time; common tower clock.

(*h*) *Chronometer:* mean time; makers, (1) DENT No. 2749, (2) BLACKIE No. 789.

(*i*) *Miscellaneous:* Sextant, by BLUNT, of New York City.

SOUTH BETHLEHEM, *Pennsylvania.*

Sayre Observatory of Lehigh University.

Longitude from Washington, $6^m\ 40^s.19$ E.

Latitude, 40° 36′ 23″.89 N.

Director: C. L. DOOLITTLE.

Founded in 1877, in connection with Lehigh University.

INSTRUMENTS:

(*c*) *Equatorial instrument:* makers, CLARK & SONS; aperture of objective, 6 inches; magnifying powers of eye-pieces, 12 to 225.

(*g*) *Clock:* sidereal; makers, BOND & SON.

(*i*) *Miscellaneous:* A portable transit instrument by STACKPOLE, a zenith telescope by **BLUNT**, and a prismatic sextant by **PISTOR & MARTIN.**

OBSERVATIONS DURING THE PAST YEAR:

Besides the work of instruction, the principal work of the Observatory has been a series of measurements of position angles and distances of Jupiter's satellites, and of their eclipses.

WORK PROPOSED FOR THE COMING YEAR (1881):

Observations of Jupiter will be kept up, with such attention to comets as circumstances will permit.

SOUTH HADLEY, *Massachusetts.*

Observatory at Mount Holyoke Seminary.

Longitude from Washington, ——?

Latitude, ——?

Through the liberality of Mr. A. L. **WILLISTON**, of Northampton, the seminary has recently been enabled to erect a small but very complete astronomical Observatory, supplied with all the necessary instruments. It is designed to furnish the means for instruction to any who may wish to make the subject a specialty, and to give opportunity to any of the teachers or post-graduates who may take an interest in astronomy to make observations of real value.

The building, of wood, consists of a tower with a dome 18 feet in diameter, flanked by two wings, one extending to the east and one to the north. The dome is very light, and rotates so easily that even the feeblest of the young ladies can manage it without difficulty. The arrangements for opening and closing the shutters which cover the slit in the dome, and the openings for the transit and prime vertical instrument, are worked with equal facility. In the dome is mounted a fine 8-inch equatorial by **CLARK**, completely fitted out with clock-work, finding-clock, micrometers, spectroscope, solar eye-piece, &c., and so arranged that the circles can be read and the clamps and tangent screws worked from the eye-piece of the instrument.

The object-glass is almost entirely the work of the senior **ALVAN CLARK**, and is one of the most perfect specimens of his art.

In the transit-room is mounted a meridian circle by **FAUTH & CO.**, of Washington. The instrument has a telescope of 3 inches aperture, and circles of 16 inches diameter, reading to seconds by two microscopes. It has a reversing apparatus, and is fitted with a "latitude level" and micrometer, so that it can, if desired, be used as a zenith telescope. A large collimator is mounted upon a pier south of it, and in a corner of the room is a clock with **DENISON** escapement, also by **FAUTH & CO.**, as is the chronograph, which is mounted in an adjoining closet. The Observatory possesses also a sextant and artificial horizon and a set of smeteorological apparatus.

There is no instrument in the prime vertical room (which is used mainly as a waiting-room or for recitations), but it is provided with a pier and shutter, so that the meridian circle can be set up there if it is ever thought desirable to make observations in that plane.

The building and its equipment have cost not far from $10,000.

C. A. YOUNG.

TARRYTOWN, *Westchester County, New York.*

Private Observatory.

Longitude from Washington, $12^m\ 47^s.16$ E.

Latitude, 41° 04′ 21″ N.

Authority for latitude and longitude: United States Coast Survey.

Director: CHARLES H. ROCKWELL.

INSTRUMENTS:

(*c*) *Equatorial instrument:* makers,—glass, Dr. C. S. HASTINGS;—mounting, JOHN BYRNE; aperture of objective, 6¼ inches; magnifying powers of eye-pieces, 60, 112, 170, 243, 327, 409, 751.

ADDITIONAL INFORMATION:

The equatorial has been mounted in a new observatory 12½ feet diameter of dome. A chronodeik for equal altitude observations has been added to the instruments mentioned in previous reports. No other changes.

TROY, *Rensselaer County, New York.*

Williams Proudfit Observatory.

Longitude from Washington, $13^m\ 27^s.5$ E. (nearly).

Latitude, 42° 43′ 52″ N.

Authority for latitude and longitude: Latitude determined by observations with the zenith telescope; longitude by electro-magnetic signals from United States Naval Observatory.

Director: Professor DASCOM GREENE.

Assistant: PALMER C. RICKETTS.

INSTRUMENTS:

(*b*) *Meridian transit instruments:* one made by E. KÜBEL, Washington; aperture, 2.5 inches; magnifying power, 60 diameters: (*b′*) one made by PHELPS & GURLEY, Troy; aperture, 2 inches; magnifying power, 30 diameters.

(*c*) *Equatorial instrument:* maker, HENRY FITZ, New York; aperture of objective, 3.5 inches; magnifying powers of eye-pieces, 45 to 200 diameters.

(*g*) *Clocks:* one mean time; maker, STOKELL, New York; one by HOWARD, Boston.

(*h*) *Chronometer:* sidereal; maker, J. Fletcher, London.

(*i*) *Miscellaneous:* Sextant; Troughton & Simms, London.

Observations during the past year (from September, 1879, to September, 1880):

Besides regular transit observations for time, by the director and assistants, the instruments have been used by the senior class of the Rensselaer Polytechnic Institute for practice in astronomical observations.

Work proposed for the coming year (1880–'81):

This is expected to be similar to the work of the past year.

Washington, *District of Columbia.*

United States Naval Observatory.

Longitude from Greenwich, $5^h\ 8^m\ 12^s.09$ W.

Latitude, $38^\circ\ 53'\ 38''.8$ N.

Directors: M. F. Maury, 1844;
J. M. Gilliss, 1861;
C. H. Davis, 1865;
B. F. Sands, 1867;
Rear-Admiral John Rodgers, U. S. N., 1874.

Assistants:
1. Prof. A. Hall,
2. Prof. W. Harkness,
3. Prof. J. R. Eastman,
4. Prof. E. S. Holden,
5. Prof. E. Frisby,

} *Professors, U. S. Navy.*

6. Mr. A. R. Skinner,
7. Mr. H. W. Paul,
8. Mr. H. S. Pritchett,

} *Permanent Assistant Astronomers.*

9. Mr. J. A. Rogers, *Temporarily employed in photographic experiments.*
10. Mr. W. F. Gardner, *Instrument-maker.*

Created by the Navy Department in 1833. Transferred in 1843 to University Square. In 1872 it came into possession of an equatorial of Alvan Clark & Son, 32½ feet ($9^m.9$) in focal length, and with an aperture of 26 inches ($0^m.65$); by means of which A. Hall discovered the two satellites of Mars in 1877.

Instruments:

(*a*) *Meridian circle:* one; makers, Pistor & Martins; diameter of circles, 43.40 inches; divided to 2′; read by 4 microscopes to 0″.1; aperture of objective, 8.52 inches; for observations of the sun, aparture employed, 3 inches; magnifying power ordinarily employed, 186 diameters.

(*b*) *Meridian transit instruments:* one made by Ertel & Son; aperture 5.33 inches; magnifying powers, 85, 86, 106, 118, 162. (*b′*) Eight portable transits and zenith telescopes combined, used on Transit of Venus Expeditions.

(*c*) *Equatorial instruments:* one made by **ALVAN CLARK & SONS**; aperture of objective, 26 inches; magnifying powers of eye-pieces, 126 to 1600. (*c'*) One made by **MERZ**: 9.62 inches aperture; powers, 90 to 900. (*c''*) Eight 5-inch equatorials by **ALVAN CLARK & SONS**, used on Transit of Venus Expeditions.

(*e*) *Photometer:* one nebula-photometer (Hastings' pattern) for use with the 26-inch equatorial.

(*f*) *Chronographs:* some 10 or 12 in all, of various kinds.

(*g*) *Clocks:* mean time, two; sidereal, six.

(*h*) *Chronometers:* mean time; all the chronometers of the United States Navy are kept here. Sidereal, eight, by **NEGUS**.

WORK PROPOSED FOR THE COMING YEAR:

The same as in former years.

ADDITIONAL INFORMATION:

[The following is a short abstract of the annual report of the Superintendent of the Observatory to the Chief of the Bureau of Navigation, and in it will be found details additional to the information presented above.—E. S. H.]

UNITED STATES NAVAL OBSERVATORY,
Washington, October, 20, 1879.

* * * * * * *

The 26-inch equatorial.—This instrument has been in charge of Prof. **ASAPH HALL**, with Prof. **EDWARD S. HOLDEN** as assistant until February, 1880; since which time Prof. **EDGAR FRISBY** has been the assistant. The instrument is now in good order, and it is in constant use. It has been employed as in previous years in the observation of satellites, double stars, and nebulæ.

The transit circle.—This instrument has been employed during the year under the direction of Prof. J. R. **EASTMAN**, who was assisted by Prof. **EDWARD S. HOLDEN** as an observer since April 1, 1880; Prof. **EDGAR FRISBY** until December 10, 1879; Assistant Astronomer A. N. **SKINNER** during the year; Assistant Astronomer H. M. **PAUL** until his resignation, July 1, 1880, and Assistant Astronomer H. S. **PRITCHETT** until his resignation, February 1, 1880. Mr. **MILES ROCK** has been employed as a temporary assistant astronomer since July 1, 1880; and Mr. **WILLIAM C. WINLOCK** has been similarly employed since August 2, 1880. Mr. **WINSLOW UPTON** has been employed as a computer since July 16, 1880. Lieut. E. **LONGNECKER** and Lieut. A. H. **VAIL** have been employed in reducing transit-circle observations, the former during the year and the latter since April 23, 1880.

The observations have been confined to—

1. Stars of the American ephemeris for clock and instrumental corrections.
2. Sun, moon, major and minor planets.
3. Stars whose occultations were observed in connection with observations of the transit of Venus in 1874.
4. Standard stars for a catalogue of zone observations.
5. Such stars of the British Association catalogue between 120° 0'

and 131° 10′ N. P. D. as have not been observed here three times in both right ascension and declination.

6. Stars used in observations of comets with the 26-inch and 9.6-inch equatorial.

7. Stars used in the determination of latitude by the United States Coast and Geodetic Survey, the Lake Survey, Capt. G. M. WHEELER'S Survey, and by Lieut. Commander F. M. GREEN in surveys in the West Indies.

The whole number of observations made with the transit circle since the last report is 4,140. Of these observations, 68 were of the sun, 62 of the moon, 145 of the major planets, and 115 of the minor planets.

The printing of the annual volume for 1876 has been delayed several months by lack of funds, but it is now nearly done. Of the transit circle work, that for 1877 is ready for the printer; the reductions of the 1878 observations are nearly finished; those of 1879 are nearly finished to apparent place; while those of 1880 are as far advanced as the nature of the work will permit.

The 9.6-*inch equatorial.*—This instrument is under the direction of Prof. J. R. EASTMAN, who has the same assistants as on the work with the transit circle. It has been employed in the observations of comets and occultations of stars, and also in determining the approximate corrections to the ephemerides of such minor planets as are not readily found with the transit circle.

The meteorological department is under the direction of Professor EASTMAN, and the usual observations, at intervals of *three hours*, beginning at midnight, have been made throughout the year by the watchmen, Messrs. HAYS, HORIGAN, and CAHILL.

Astronomical photography.—The experiments in astronomical photography, including the reduction of the photographic observations of the transit of Mercury in May, 1878, are under the charge of Prof. WM. HARKNESS, who has been assisted by Master E. F. QUALTROUGH and by Mr. JOSEPH A. ROGERS.

At the date of my last report the reductions of the Ann Arbor photographs of the transit of Mercury were suspended because the reticule plate used in making the pictures had not been returned to this observatory. Since then the plate has been received, and the work of reducing the photographs has made considerable progress.

An investigation has just been commenced for the purpose of obtaining some light on the following questions, namely:

1st. What are the capabilities of objectives of various sizes for astronomical photography, and what are the approximate exposure coefficients for the different classes of celestial objects?

2d. What form of an apparatus is best adapted for photographing the corona during total solar eclipses, and what exposure coefficient is likely to be required?

3d. What kind of pyroxylene is best adapted for astronomical photography, and how can it be produced with certainty? Much time has been spent in planning these experiments, and in devising suitable apparatus for executing them, and it is hoped that they will lead to practical results.

Solar eclipses of July 29, 1878, *and January* 11, 1880.—The reports on these eclipses have been collected into a volume (which is noticed elsewhere).

The first part of the Transit of Venus papers, embracing the history and general discussion, is in the hands of the printer, and the composition is about complete. The press-work was, however, postponed on account of the incomplete state of the general reductions of the observations to appear in Part II. These reductions cannot be completed without a small additional appropriation for the purpose.

The library.—The library contains 8,500 volumes, distributed about as follows:

I. Works on astronomy, mathematics, geodesy, physics, meteorology, and geography, including transactions of learned societies—about 6,200 volumes.

II. Pamphlets on the same subjects, each one separately bound in paper covers, placed in drawers, and classified by subjects—about 1,000 numbers.

III. Miscellaneous works of reference, &c., in the office of the Superintendent—about 700 volumes.

IV. Publications of the United States Senate and House of Representatives—about 600 volumes.

Total, 8,500 volumes.

A card catalogue of about 16,000 cards has been completed. It is not necessary to print this at present. After the cards become soiled by use, they should be printed to preserve them.

Distribution of the publications of the Observatory.—A list of 921 names has been prepared, and to these correspondents our publications are distributed. Academies of science, public observatories, and the principal colleges, receive the complete volumes. The appendices are distributed to all observatories, to the principal astronomers, and others interested in astronomy.

In return for this liberal distribution, the library receives, free of cost, the publications of the principal observatories, learned societies, &c., of the world.

Since February, 1879, about 12,000 separate numbers of our publications have been distributed. These were mostly to fill sets which had been left incomplete in former distributions. At present all our correspondents have complete sets of our volumes, as far as we can supply them.

In addition to his duties as librarian, Professor HOLDEN takes his regular tour of duty as an observer on the transit circle; and he has made a set of drawings of the planets Saturn and Jupiter, with the 26-inch equatorial, and a series of measures of the dusky ring of Saturn, in continuation of those made in 1879.

During the year the Western Union time-ball in New York has failed nine times: once on account of a heavy snow-storm; four times owing to interruption to the Western Union lines; and four times owing to accidents to machinery. The Washington time-ball has failed twice, owing to accidents to machinery.

WEST POINT, *New York.*

West Point Observatory.

Longitude from Washington, $12^{m}\ 22^{s}.71$ E.
Latitude, $41^{\circ}\ 23'\ 31''$ N.
Director: ———.

WILLETS POINT, *Queens County, New York.*

Field Observatory—Engineer School of Application.

Longitude from Washington, $13^m\ 04^s.57$ E. ± $0^s.14$.

Latitude, 40° 47′ 21″.59 N. ± 0″.08.

Latitude determined by observations with zenith telescope. Longitude determined by telegraphic time-signals from Naval Observatory, Washington.

Director: General **HENRY L. ABBOT.**

Assistant: Capt. **J. C. MALLERY.**

INSTRUMENTS:

(*b*) *Meridian transit instruments:* (*Four:*) One, makers, **LINGKE & CO.**, Silesia; aperture, 2½ inches; magnifying power, — diameters; focal length, 30 inches. One, Russian transit, aperture, 2.6 inches; **STACKPOLE & BRO.**, New York; focal length, 30 inches. One, **TROUGHTON**, aperture, 2 inches; **TROUGHTON**, London; focal length, 30 inches. One, **STACKPOLE**, aperture, 2 inches; **STACKPOLE & BRO.**, New York; focal length, 24 inches.

(*c*) *Equatorial instrument:* makers, **FAUTH & CO.**, Washington; aperture of objective, 5½ inches; magnifying powers of eye-pieces, assorted.

(*f*) *Chronographs:* **HIPP'S**; **NEGUS-MORSE** register.

(*h*) *Chronometers:* one mean time; makers, **ARNOLD & DENT**: one sidereal; makers, **LUKENS**; **BOND & SON**. Both break-circuit.

(*i*) *Miscellaneous:* One portable telescope, equatorially mounted; one zenith telescope—**WILLIAM WÜRDEMANN**; two sextants, **STACKPOLE & BRO.**; one personal equation machine; one barometer, **GREEN'S** cistern.

OBSERVATIONS DURING THE PAST YEAR:

Observations for determining latitude and longitude, for instruction of engineer officers at the school.

Observations upon auroral displays, extended through entire night, and continued since 1870.

WORK PROPOSED FOR THE COMING YEAR (1881):

Similar to above.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR:

Annual battalion order announcing results of season's works.

ADDITIONAL INFORMATION:

Observations on the Aurora Borealis.—The regular series of records of the displays of the Aurora Borealis, begun in 1870, has been continued, as heretofore. Three sentinel posts, widely separated from each other, are guarded nightly by soldiers of the Battalion of Engineers specially selected as watchmen. Eight men are thus permanently detailed. Three of them remain on duty from sunset to sunrise, and are required to report, when relieved, whether they have seen any auroral light during the night; and if not, whether the sky has been sufficiently clear to permit any to be visible. These records for the past year are presented in the following consolidated table—which, considering the difficulty of distinguishing the fainter displays, is regarded as establishing the trustworthy character of the record by the general accordance between the three independent observers. It appears that out of 216 favorable nights, 13 auroras were noted; and if we may assume the same ratio to apply to the clouded nights, about 22 auroral displays occurred during the twelve months.

Auroral displays in 1880.

Name of month.	Auroras.				Clear nights.				Clouded nights.			
	Post No. 1.	Post No. 2.	Post No. 3.	Mean.	Post No. 1.	Post No. 2.	Post No. 3.	Mean.	Post No. 1.	Post No. 2.	Post No. 3.	Mean.
January	0	0	0	0.0	15	14	15	14.7	16	17	16	16.3
February	0	0	0	0.0	16	19	17	17.3	13	10	12	11.7
March	1	2	1	1.3	15	18	16	16.3	16	13	15	14.7
April	1	2	1	1.3	16	19	19	18.0	14	11	11	12.0
May	0	1	0	0.3	18	19	19	18.7	13	12	12	12.3
June	0	0	0	0.0	19	21	18	19.3	11	9	12	10.7
July	1	1	1	1.0	17	20	18	18.3	14	11	13	12.7
August	3	3	3	3.0	18	18	18	18.0	13	13	13	13.0
September	1	1	1	1.0	18	18	19	18.3	12	12	11	11.7
October	2	2	2	2.0	21	20	21	20.7	10	11	10	10.3
November	4	1	4	3.0	17	17	14	16.0	13	13	16	14.0
December	0	0	0	0.0	21	20	19	20.0	10	11	12	11.0
Total for year	13	13	13	12.9	211	223	213	215.6	155	143	153	150.4

Summary of auroral records for eleven years.

Year.	Clear sky.		Cloudy sky.		Total for year.	Remarks.
	Nights.	Observed auroras.	Nights.	Probable auroras.		
1870	184	50	150	41	99	Begun February 1, 1870.
1871	211	60	154	44	104	
1872	234	60	132	34	94	
1873	214	54	151	38	92	
1874	190	18	175	17	35	
1875	189	14	176	13	27	
1876	195	9	171	8	17	
1877	191	7	174	6	13	
1878	185	2	180	2	4	
1879	204	9	161	7	16	
1880	216	13	150	9	22	

These observations were undertaken to throw light upon the supposed connection between the number of solar spots and the frequency of auroras and of magnetic disturbances. They have now been continued long enough to give interest to the foregoing summary compiled from the general orders above cited. No corresponding record of solar spots during this period of eleven years is at hand for precise comparison; but such records have been preserved, and they show the number of spots in the year 1870 to be a maximum and in 1878 a minimum. It will be noted that these years are nearly those of maximum and minimum observed auroras.

WILLIAMSTOWN, *Massachusetts.*

Williamstown Observatory.

Longitude from Washington, 15m 18s.6 E.
Latitude, 42° 42′ 49″ N.
Director: ———?

YPSILANTI, *Washtenaw County, Michigan.*

State Normal School Observatory.

Longitude from Washington, 26m 10s W.
Latitude, 42° 13′ N.
Authority for latitude and longitude: J. C. WATSON.
Director: LEWIS MCLOUTH, M. A.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* maker, GURLEY, Albany; aperture 1½ inches; magnifying power, 30 diameters.

(*c*) *Equatorial instrument:* maker, A. CLARK, Cambridgeport, Mass.; aperture of objective, 4 inches; magnifying powers of eye pieces, 45, 90, 144, 210.

(*d*) *Spectroscope:* BROWNING, London, 2 prism.

(*h*) *Chronometer:* sidereal; maker, NEGUS.

(*i*) *Miscellaneous:* The observatory building is completed. No systematic work has been done. The building is small, and its equipment is for instruction rather than investigation. The equatorial is quite good —the one with which Professor WATSON made his observations on the supposed planet Vulcan.

II. FOREIGN OBSERVATORIES.

ABERDEEN, *Scotland.*

See *Dun Echt.*

ABO, *Russia.*

Abo Observatory.

Longitude from Greenwich, 1h 29m 8s.2 E.
Latitude, 60° 26′ 56″.8 N.
Director: ———?

ADELAIDE, *South Australia.*

Observatory Branch of Post-Office and Telegraph Department.

Longitude from Greenwich, 9h 14m 21s E.
Latitude, 34° 57′ S.
Director: C. TODD, 1860.

"Our Observatory is but a young institution, but Parliament has recently voted over £3,000 for instruments and buildings, including a large *Transit circle*, and a barograph, thermograph, Kew anemometer, &c. We already possess a fine *Equatorial*, with which good work is done."

C. TODD,
Government Astronomer.

ALGIERS, *Algeria.*

Observatoire National.

Longitude from Greenwich, 12m 11s.39 E.
Latitude, 36° 45′ 2″.7 N.
Director: ——— ?

ALTONA, *Prussia.*

Sternwarte.

Longitude from Greenwich, 39m 46s.35 E.
Latitude, 53° 32′ 45″.3 N.
Built upon the ramparts in 1815; transferred to Kiel in 1873. (See Kiel.)
Directors: H. C. SCHUMACHER, 1816;
A. C. PETERSEN (transient), 1851;
P. A. HANSEN, 1852;
C. A. F. PETERS, 1855.

ARMAGH, *Ireland.*

Observatory.

Longitude from Greenwich, 26m 35s.5 W.
Latitude, 54° 21′ 12″.7 N.
Founded in 1792 as a dependency of the University.
Directors: J. A. HAMILTON, 1792;
T. R. ROBINSON, 1825.

ATHENS, *Greece*.

Observatory.

Longitude from Greenwich, $1^h\ 34^m\ 55^s.7$ E.
Latitude, 37° 58′ 20″ N.
Commenced in 1845. Erected through the liberality of Baron VON SINA, in Vienna. It has a dome containing a refractor of 6.7 inches ($0^m.17$) aperture.

Directors: G. C. BONRIS, 1844;
J. F. J. SCHMIDT, 1858.

BASLE, *Switzerland*.

Physikalisches Institut.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ED. HAGENBACH.

INSTRUMENTS:

(*a*) The *Meridian circle*, constructed by the Société Genevoise, with 2½-inch objective, by C. A. STEINHEIL.

(*c*) The *Equatorial*, made by the "Société Genevoise pour la construction d'instruments de physique" mounted on an isolated pillar, under a movable dome of 16½ feet (5 meters) diameter. The instrument is provided with a centrifugal regulator, constructed according to Prof. M. THURY's directions, with position micrometer, spectroscope, and camera obscura.

(*d*) *Spectroscope.*

(*g*) The *astronomical clock* was constructed by THEODOR KNOBLICH, in Hamburg.

The mean time is given by means of an electric pendulum, by M. HIPP, in Neuenburg.

Both clocks connect with a number of dials in various rooms, and also with the chronograph.

BERGEN, *Norway*.

Naval Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Founded in 1788. So far has only been used to furnish the standard time.

Directors: C. F. G. BOHR, 1818;
J. J. ASTRAND, 1833. (?)

BERLIN, *Prussia.*

Königliche Sternwarte.

Longitude from Greenwich, $53^m\ 34^s.91$ E.
Latitude, 52° 30′ 16″.7 N.
Directors: G. KIRCH, 1706;
J. H. HOFFMANN, 1710;
C. KIRCH, 1717;
J. W. WAGNER, 1740;
H. N. GRISCHOW, 1745;
J. KIES, 1754;
F. U. S. AEPINUS, 1755;
J. J. HUBER, 1756;
JEAN BERNOULLI, 1767;
J. E. BODE, 1786;
J. F. ENCKE, 1825;
W. J. FOERSTER, 1865.
Librarian: Dr. V. KNORRE.

Founded at the request of LEIBNITZ in 1705; completed in 1711. Originally situated in the suburb Dorotheenstadt, in the northern part of the city. A great square tower of five stories, 46 feet (14 meters) in length and 88½ feet (27 meters) in height. This Observatory was remodelled in 1787 and again in 1800. In 1833 a new Observatory was built at the southern extremity of the Charlotten Strasse. The "Astronomische Jahrbuch" has been published annually since 1776. It was here that GALLE discovered Neptune in 1846.

BERN, *Switzerland.*

Sternwarte.

Longitude from Greenwich, $29^m\ 46^s$ E.
Latitude, 46° 57′ 8″.7 N.
Directors: F. FRECHSEL, 1821;
R. WOLF, 1847;
J. KOCH, 1856;
H. WILD, 1859;
A. J. T. FORSTER, 1871.

Constructed upon a bastion in 1822. In plan a regular octagon, the circle described about which has a diameter of 65½ feet (20 meters).

BIRR CASTLE, *Ireland.*

Parsons-town Observatory.

Longitude from Greenwich, $31^m\ 40^s.9$ W.
Latitude, 53° 5′ 47″ N.
Director: The EARL OF ROSSE.

INSTRUMENTS:

It is here was erected the celebrated sixty-foot reflecting telescope, with a six-foot speculum.

BOGOTA, *United States of Colombia.*

Bogota Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Recently founded.
Director: GONZALES.

BOLOGNA, *Italy.*

Osservatorio Astronomico.

Longitude from Greenwich, 45^m $24^s.6$ E.
Latitude, 44° 29′ 47″ N.

BOMBAY, *India.*

Government Observatory at Colaba.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: CHARLES CHAMBERS.

The principal work of the Colaba Observatory is in the fields of terrestrial magnetism and meteorology, and astronomical observations are made only for the practical purpose of time keeping, partly for the public service and partly for the use of the Observatory.

BONN, *Prussia.*

Universitäts Sternwarte.

Longitude from Greenwich, 28^m $23^s.29$ E.
Latitude, 50° 43′ 45″ N.
Directors: K. D. VON MÜNCHOW, 1818;
F. W. A. ARGELANDER, 1837;
E. SCHÖNFELD, 1875.

Founded in 1818 near the University. The erection of a more complete Observatory was decided upon in 1837, and the new establishment was finished in 1840. It includes two halls for meridian instruments and five turrets. Here it was that the review of the heavens, known under the name of "Durchmusterung," was undertaken and accomplished under the direction of ARGELANDER, including all stars up to the ninth magnitude.

BOTHCAMP, *near Kiel, Prussia.*

Observatory.

Longitude from Greenwich, $40^m 30^s.8$ E.
Latitude, 54° 12′ 9″.6 N.
Director: ——— ?

BORDEAUX, *France.*

Observatoire.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

BREMEN, *Germany.*

Observatorium der Navigations Schule.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

BRESLAU, *Prussia.*

Universitäts Sternwarte.

Longitude from Greenwich, $1^h 8^m 8^s.71$ E.
Latitude, 51° 6′ 56″.5 N.
Directors: J. E. SCHEIBEL, 1759;
L. A. JUNGNITZ, 1780;
H. W. BRANDES, 1809;
P. H. L. VAN BOYNSLAEVSKI, 1827;
Prof. Dr. J. G. GALLE, 1852.

Observations here were begun about 1760 at the gymnasium, where the professor of mathematics had collected a few instruments. They were continued at the University, and the Observatory properly so called was gradually developed.

BRUSSELS, *Belgium.*

Observatoire Royale.

Longitude from Greenwich, $17^m 28^s.6$ E.
Latitude, 50° 51′ 10″.5 N.
Directors: L. A. J. QUETELET, 1829·
J. C. HOUZEAU, 1876.

Projected in 1826, begun in 1829, completed in 1834. A large hall for meridian observations is located between two wings, each surmounted by a turret.

BUDAPESTH, *Hungary.*

K. K. Sternwarte.

See *Ofen.*

CADIZ, *Spain.*

Naval Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?

CAIRO, *Egypt.*

Observatoire Khédivial.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: MAHMOUD.
Founded about 1850.

CAMBRIDGE, *England.*

Cambridge Observatory.

Longitude from Greenwich, $22^s.75$ E.
Latitude, 52° 12′ 51″.6 N.
Directors: W. LUDLAM, 1767;
A. SHEPHERD, 1769;
S. VINCE, 1797;
R. WOODHOUSE, 1820;
G. B. AIRY, 1827;
J. CHALLIS, 1836;
J. C. ADAMS, 1860.

Commenced at Christ College; removed to St. John's College in 1767. In 1764 a special location was assigned to it above the entrance gate ot Trinity College. The senate of the University caused a better Observatory to be erected in 1820, which was completed in 1824. The structure consists of four halls forming a cluster of buildings.

CAPE TOWN, *Africa*.

Royal Observatory, Cape of Good Hope.

Longitude from Greenwich, $1^h\ 13^m\ 55^s$ E.
Latitude, 33° 56′ 3″.4 S.
Authority for longitude, **HENDERSON**; for latitude, **STONE**.

Directors: F. **FALLOWS**, 1820;
T. **HENDERSON**, 1831;
T. **MACLEAR**, 1834;
E. J. **STONE**, 1870;
DAVID GILL, 1879.
Assistants: W. H. **FINLAY**;
G. **MACLEAR**;
ROBT. H. PELT;
I. **FREEMAN**.

Founded in 1820. Owned no instruments of importance until 1829. It was not at this Observatory that **JOHN HERSCHEL** made his observations, but some distance from here on a private estate called **FELDHAUSEN**.

INSTRUMENTS:

(*a*) *Meridian circle*, by **RANSOME & SIMMS** for the engineering part; **TROUGHTON & SIMMS** for micrometric and optical part; a sister instrument to the Greenwich circle; diameter of circles, 66 inches; divided to 5′; read by 6 microscopes to 0′.01 estimating easily to 0′.001 as at Greenwich. Aperture of objective, 8 inches; magnifying power always employed, 200 diameters.

(*c*) *Equatorial instruments:* makers, object-glass by **MERZ**, mounting (German form) by **TROUGHTON & SIMMS**; aperture of objective, 6.9 inches; magnifying power of eye-pieces, 40 to 400. (*c*′) Small equatorial, 3.6-inch aperture (**DOLLARD**), 46 inches focal length, mounting on long polar axis (English form), maker unknown; without clock-work, at present dismounted.

(*d*) *Spectroscope:* spectroscope by **TROUGHTON & SIMMS**.

(*f*) *Chronograph:* one by **BOND**, not at present in use.

(*g*) *Clocks:* one mean time; maker, **MOLYNEUX**: one sidereal; * maker, **BARRAUD**.

(*h*) *Chronometers:* mean time and sidereal. A supply of these instruments kept for use of Her Majesty's ships, consequently frequently changed.

(*i*) *Miscellaneous:* A heliometer of 5 feet focal length, 4 inches (French) aperture. Tube and cradle by **REPSOLD**, mounting by **GRUBB**. (This instrument is the private property of Mr. **GILL**.)

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* A new normal clock, with **AIRY'S** escapement and air-tight case, is in course of construction by Messrs. **DENT**.

OBSERVATIONS DURING THE PAST YEAR (from January 1, 1880, to January 1, 1881):

(*a*) Fundamental stars for Schoenfeld's "Durchmusterung."

Additional stars of N. and S. declination for investigations connected with refraction.

Daily observations of α and β Centauri for parallax.

Small list of stars observed at request of Dr. AUWERS.

Selected list of circumpolar stars.

Long series of observations connected with investigations on personal equation.

List of stars to be used in connecting longitudes of Aden and Cape of Good Hope.

(*c*) Every star, down to 6th of May, occulted by the moon has been observed when weather permitted. Every eclipse of Jupiter's satellites has been observed when weather permitted.

(*i*) The heliometer arrived in December. Observations with that instrument for annual parallax of β *Centauri*, ε *Indi* and β *Hydri* have been commenced.

WORK PROPOSED FOR THE COMING YEAR (1881):

Completion of observations of SCHOENFELD'S fundamental stars.

Completion of personal equation investigations.

Continuation of observations of α and β Centauri.

Completion of a useful catalogue of southern circumpolars for observers of transit of Venus, 1882.

Completion of longitude connection of Aden and Cape of Good Hope.

Researches with the heliometer on parallax of fixed stars.

Continuance of series of observations of occultations of stars by the moon and eclipses of Jupiter's satellites. Arrangements being made for application of photometer to these latter observations, as at Cambridge, United States.

ADDITIONAL INFORMATION:

There have been no publications of the observatory issued during the past year (1880). The great catalogue of 12,400 stars, deduced from observations 1870–'79, was taken to England in 1879 by Mr. STONE for publication, together with the annual volumes for 1877–'78 in MSS. Owing to necessary alterations in the microscopes of the transit circle, and to some other instrumental changes, the new series of N. P. D. work was not begun till March, 1880. The completion of one series of observations and the commencement of another creates a gap in the plan of publications. The Cape catalogue for 1850, deduced from Maclear's observations in 1849, '50, '51, and '52 is nearly completed. It contains all stars of the B. A. C. catalogue having south declination.

There are also under preparation for press:

Occultations of stars by the moon (about 400 in number) observed between 1834 and 1870, reduced and compared with tables.

A series of observations of double stars made between 1849 and 1868 (chiefly observations of *a Centauri*, and some of the most interesting southern double stars).

CATHARINEBURG, *Russia*.

Astronomical, Magnetical, and Meteorological Observatory.

Longitude from Greenwich, 4h 2m 48s E.

Latitude, 56° 49′ N.

Authority for latitude and longitude: KUPFFER (1841); FRITSCHE (1873 and 1876); SCHARNHORST and KUHLBERG (1875).

Director: G. O. CLERC, secretary Natural History Society.

Observers: V. A. BABKIN;
A. M. CHECHULIN.

(*b*) *Meridian transit instrument:* makers, ERTEL & SOHN (small passage instrument); aperture, 1.5 inches. (*b′*) Another by BRAUER in St. Petersburg (universal instrument).

(*g*) *Clocks:* one mean time; maker, F. FLAUTH, in St. Petersburg (without No.); another regulator, without name.

(*h*) *Chronometers:* mean time; makers, F. FLAUTH, No. 37; WIREN, No. 86.

(*i*) *Miscellaneous:* Magnetic theodolite, BRAUER, No. 37; BRAUER'S compass for magnetical declination and intensity; GAMBEY'S inclinatorium; variation magnetometers (syst. GAUSS); several series of meteorological instruments of different construction; thermometers for observation of the temperature from superficy to three meters depth.

OBSERVATIONS DURING THE PAST YEAR:

(*a*) The passage instrument was used every day whenever the weather permitted, for determination of time by observation of the sun.

WORK PROPOSED FOR THE COMING YEAR (1881):

Magnetic and meteorological observations; elaboration of those observations.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR 1880:

The observatory does not print anything; all its observations appear in the annals of the central Observatory at St. Petersburg.

G. O. CLERC: Débacle de la Tchonsdomia (Russ. and French), p. 83, vol. v, "Bulletin de la Société ouralienne des sciences naturelles."

G. O. CLERC: Translations from German into Russian, and from Russian into French, in the 5th and 6th vols. of the "Bulletin de la Société ouralienne des sciences naturelles."

CHAPULTEPEC, *Mexico.*

National Observatory.

Longitude from Greenwich, $6^h\ 36^m\ 38^s.24$ W.
Latitude, 19° 25′ 17″.5 N.
Director: A. **ANGUIANO**, 1878.
Projected in 1876; established in 1878.

CHRISTIANIA, *Norway.*

Universitäts Sternwarte.

Longitude from Greenwich, $42^m\ 53^s.65$ E.
Latitude, 59° 54′ 43″.7 N.
Authority for latitude and longitude: Beschreibung und Lage der Universitäts Sternwarte in Christiania; Verhandlung der fünften allgemeinen Conferenz der europäischen Gradmessung, p. 300. Expéd. chronom. exécutée en 1844 entre Alton and Greenwich.
Directors: C. **HANSTEEN**, 1815;
C. **FEARNLEY**, 1873.
Observer: H. **GEELMUYDEN**.
Watchman: J. **THRONDEN**.
Projected in 1815; constructed in 1818; rebuilt at some distance from the first structure in 1830.

INSTRUMENTS:

(*a*) *Meridian circles:* one; makers, **ERTEL**, with objective by **FRAUENHOFER** and **UTZSCHNEIDER**: diameter, 38 inches; divided to 3′, read by 4 microscopes to 2″; aperture of objective, 4 inches; magnifying power, 180 diameters.

(*b*) *Portable transit instrument:* **PISTOR** & **MARTINS**, makers; aperture of objective, 2 inches; magnifying power, 80 diameters.

(*c*) *Equatorial* by A. & G. **REPSOLD**. Diameter of circles, 30 inches, divided to 3′; read by 2 microscopes to 1″; aperture of objective, 4½ inches; magnifying power, 50–290. Wire micrometer and ring micrometer. (*c′*) Refractor: Makers, G. **MERZ** & **SÖHNE**; objective, 7 inches; magnifying power, 80–600; diameters of circles 10 and 14 inches; read by 2 Noniers each to 4^s and 10″. Wire micrometer.

(*d*) Small universal star-spectroscope by **MERZ**, à vision directe.

(*g*) *Clocks:* one sidereal: pendulum, by **KESSELS**, 1365; one mean time, by **URB. JÜRGENSEN OG SÖNNER** (for the bifilar): one by L. **LAMTVORK** (for the unifilar); F in the magnetic building.

(*h*) *Chronometers:* mean time; (Box) **KESSELS**, 1259; (Pocket) **KESSELS**, 1280: one sidereal; **DENT**, 2103.

(*i*) Unifilar magnetometer, by **MEYERSTEIN**; bifilar magnetometer, by MEYERSTEIN; inclinatometers, by GAMBEY, BARLOW, Dover; siphon barometer, by PISTOR; cistern barometer, by FORTIN; thermometers, pluviameters, &c.

OBSERVATIONS DURING THE PAST YEAR:

Supplementary observations of zone stars between 64° 50′ and 70° 10′ N. declination (for the astronomical society). Regular time determination (for the benefit of navigation), sent twice a week to all Norwegian ports.

(*b*) Observations for determination of longitude between Christiania and Bergen.

(*c*) Observations on Comet Hartwig (1880 *d.*). (*c′*) [1879. Observations for the preliminary parallax determination of Argel. Oeltz, 11677.]

(*d*) [1873-'74. Drawings and measurements of protuberances.]

(*i*) Magnetic observations (twice a day). Meterological observations (fifteen every day).

ADDITIONAL INFORMATION:

Six astronomical lectures every week by the director, and 3 to 4 by the observer.

Observations for the European "Gradmessung" were made for the determination of azimuth and pole distance, by the director, during the months of July and August, at a trigonometrical station near Drontheim.

CHURTS, *England*.

Private Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: R. CARRINGTON.

COIMBRA, *Portugal*.

Observatorio Magnetico-Meteorologico de la Universidade de Coimbra.

Longitude from Greenwich, $33^m\ 34^s.5$ W.
Latitude, 40° 12′ 25″.8 N.
Directors: J. MONTEIRO DE ROCHA, 1796; (?)
DE PINHEIRO, 1820;
DE SOUZA PINTO, 1855. (?)

Established about 1796. From 1799 to the present time the Astronomical Ephemeris has been published here, which for ten years previous (since 1789) had been issued at Lisbon.

COLLOONEY, *Ireland.*

Markree Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ———?

COLOMBO, *Ceylon, Asia.*

Private Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: Mr. —— GREEN.

COPENHAGEN, *Denmark.*

Universitets Astronomiske Observatorium.

Longitude from Greenwich, 50^m $19^s.2$ E.
Latitude, 55° 41′ 13″.6 N.
Director: ——— ?

CORDOBA, *Argentine Republic.*

Observatorio Naçional Argentino.

Longitude from Greenwich, 4^h 16^m $45^s.1$ W.
Latitude, 31° 25′ $15^s.4$ S.
Director: B. A. GOULD, 1870.

Proposed in 1869; built in 1871 on an eminence southeast of the town; a cruciform structure, with four towers at the extremities of the limbs of the cross. The *Uranometria Argentina* was constructed here, containing all the stars, up to those of the seventh magnitude, which are visible in the southern heavens.

CORK, *Ireland.*

Observatory of Queen's College.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ———?

Founded in 1878. Hall for meridian observations. Dome 14¾ feet ($4^m.5$) in diameter.

CRACOW, *Austria.*

Cracow Observatory.

Longitude from Greenwich, 1h 19m 50s.5 E.
Latitude, 50° 3′ 50″ N.
Director: ——— ?

CRONSTADT, *Russia.*

Naval Astronomical Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

DANZIG, *Prussia.*

Sternwarte.

Observatory of the Society of Naturalists (Naturforschende Gesellschaft). Established in 1783.

Longitude from Greenwich, 1h 14m 39s.3 E.
Latitude, 54° 21′ 18″ N.
Directors: J. A. **Koch**, 1783;
E. **Kayser**, 1850. (?)

DERPT (Dorpat), *Russia.*

Imperatorskaia Astronomicheskaia Observatoria.

Longitude from Greenwich, 1h 46m 53s.5 E.
Latitude, 58° 22′ 47″.4 N.
Directors: J. W. A. **Pfaff**, 1808;
F. G. W. **Struve**, 1813;
J. H. **Madler**, 1840;
T. **Clausen**, 1874;
L. **Schwarz**, 1878.

Founded in 1808, as a dependency of the University. In 1825 **Fraunhofer's** equatorial, with an aperture of 9 inches and a focal length of 13½ feet, moved by clock-work, the largest and most powerful refractor in the world at that time, was mounted there. With the help of this instrument the elder **Struve** accomplished his famous *Mensuræ Micrometricæ*, published in 1837, and continued by his successor.

DUBLIN, *Ireland.*

Dunsink Observatory.

Longitude from Greenwich, 25^m 21^s W.
Latitude, 53° 23′ 13″ N.
Authority for latitude and longitude: Dr. BRÜNNOW.
Directors: H. USSHER, 1774;
J. BRINKLEY, 1792;
W. R. HAMILTON, 1827;
F. BRÜNNOW, 1865;
Prof. ROBERT S. BALL, LL.D., F. R. S., *Astronomer Royal of Ireland*, 1875.
Assistant: J. L. E. DREYER.

Observatory of Trinity College.

Founded in 1774, by means of the legacy left for the purpose by F. ANDREWS; built in the midst of a vast park at Dunsink, 3¾ miles (6 kilometers) northwest of Dublin. It was not finished until 1792. A structure of three stories, surmounted by a revolving dome.

INSTRUMENTS:

(*a*) *Meridian circle:* makers, PISTOR & MARTINS; diameter of circles, 36 inches; divided to 2′; read by 8 microscopes to 1″; aperture of objective, 6.4 inches; magnifying power ordinarily employed, 180 diameters.

(*b*) *Meridian transit instruments:* one, made by RAMSDEN; aperture, 4 inches: not in use. (*b*′) One with reversible circle by RAMSDEN & BERGE; object-glass, 3 inches; diameter of circle, 8 feet; 3 micrometers: not in use.

(*c*) *Equatorial instruments:* one; makers, CAUCHOIX object-glass, GRUBB mounting; aperture of objective, 11¾ inches; magnifying powers of eye-pieces, 300: is generally used. (*c*′) One of four inches aperture; English equatorial by TULLEY. (?) Hardly ever used.

(*d*) *Spectroscopes:* one of BROWNING'S two-prism spectroscopes; and one of VOGEL'S small-star spectroscopes.

(*f*) *Chronograph:* maker, GRUBB; two barrels and controlled clock.

(*g*) *Clocks:* one mean time; maker, BOOTH of Dublin: one sidereal; maker, DENT, London.

(*h*) *Chronometer:* sidereal; maker, M'MASTER.

(*i*) *Miscellaneous:* The mean-time clock controls by electricity the clocks in the port and docks board and Trinity College, the distance being about five miles from Dunsink.

Dunsink Observatory belongs to Trinity College, Dublin. An annual visitation of the Observatory is held every summer by the board of Trinity College.

OBSERVATIONS DURING THE PAST YEAR (1880):

The meridian observations of red stars (commenced by Dr. COPE-

LAND in 1875–1876, and taken up by Mr. **DREYER** in September 1878), were finished in the summer 1880, each star being observed four times or oftener. The reductions to the epoch 1875.0 were nearly finished by the end of the year.

The south equatorial has been employed entirely in observations for annual parallax by Dr. **BALL**. During 1880 a series for Groombridge 1618 was completed, and from the distances of + 50°, 1724, a parallax of + 0″. 3196 ± .052 has been concluded; for Gr. 1618 a series for P III 242, recommended by **STRUVE** (M.N. vol. xx, p. 8), gives a parallax of — 0″.045 ± 0″.070 (M.N., November, 1880). A series for Schj. 249 (*a*) (red stars) has been completed, but not reduced, and a series for ω Cephei and ϵ 2486 have been commenced. The sweeping observations described in Dunsink Observations, Part III, have also been continued.

WORK PROPOSED FOR THE COMING YEAR (1881):

The meridian circle is proposed to be employed in a reobservation of **ARGELANDER'S** southern zones, commencing with the zone —15° to —20°, and extending perhaps a few degrees more south if it appears practicable.

The equatorial is proposed to be employed in a continuation of the parallax observations, much of which work is at present in hands.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY:

ROBERT S. BALL: Elements of Astronomy, London, 1 vol., 459 p.

ROBERT S. BALL: On the Parallax of P III 242. M.N., November, 1880.

J. L. E. DREYER: A record of the progress of astronomy during the year 1879. Proceedings of the Royal Dublin Society.

DUN ECHT, *Scotland.*

Private Observatory.

Longitude from Greenwich, $9^m\ 40^s$ W.

Latitude, 57° 9′ 36″ N.

Authority for longitude: Ordnance Survey; for latitude, observations with a **SIMMS** alt-azimuth. The transit circle confirms the result within a fraction of a second.

Astronomer: **RALPH COPELAND**, *Ph. D.*

Assistant: **J. G. LOHSE.**

Computer: **H. J. CARPENTER.**

General mechanic: **T. KIRKWOOD.**

Messenger and meteorology reader: **J. MCPHERSON.**

Dun Echt Observatory, the property of the Earl of Crawford and Balcarres (late Lord **LINDSAY**), is on the estate of Dun Echt, about 13 miles west of Aberdeen.

Height above the sea, 464 feet to cistern of standard barometer.

INSTRUMENTS:

(*a*) *Meridian circles:* 1. Transit circle by Troughton & Simms; one movable and one fixed circle; diameter 36 inches divided to 5″; 16 microscopes (carried by 2 Alidade circles, 1 movable and 1 fixed), reading to 1″-tenth by estimation; aperture of object-glass 8.59 inches; 6⅙-inch collimators; 2½-inch axle telescope. 2. Reversing transit with V's for meridian and prime vertical, by T. Cooke & Sons; 4-inch object-glass. 3. Transit instrument by Troughton & Simms; 2¾-inch object-glass.

(*b*) *Meridian transit instruments:* 1. Alt-azimuth, by Troughton & Simms; 12-inch circles, divided to 5′; 4 microscopes, vertical and horizontal circles reading seconds and tenths by estimation. Horizontal circle movable. 2. Theodolite by T. Cooke & Sons. 3. Theodolite by Apps.

(*c*) *Equatorial instruments:* One 15.06-inch refractor by Grubb. Several sets of eye-pieces. Bifilar micrometer. Merz helioscope. Dawes solar eye-piece, 2, 3, 74 inch finders. This telescope is controlled absolutely by the sidereal clock. Driving-clock by T. Cooke & Sons, made to special design. 2. One 12.9-inch reflector 122.5 focus; mirror by Rev. H. Cooper Key English mounting. 3. One 12¼-inch reflector by Browning. Solar spectroscope. 4. One 6.06-inch refractor by Simms; bifilar and double image micrometers, used generally for comet seeking. 5. One 6.04-inch refractor by T. Cooke & Sons. Complete. 6. One 4-inch refractor by T. Cooke & Sons; bifilar micrometer. Clock by Eichens. Complete. 7. One 3-inch refractor by T. Cooke & Sons; bifilar micrometer. Complete.

(*d*) *Spectroscopes:* Large solar spectroscope with 1 whole and 2 half Rutherfurd prisms with reversion and heliometer viewing telescope. Stellar spectroscope modified at Dun Echt (the one most used). Browning 5-prism automatic solar spectroscope and 2 stellar ones; also Vogel spectroscope by Heustrell, and a variety of direct vision, quartz, and other prisms. Besides the above-mentioned spectroscope there is a 6-prism automatic reversing table instrument by Browning, and a hand direct vision spectroscope used for Auroræ.

(*e*) *Photometer:* Zöllner astro-photometer by Ausfeld of Gotha.

(*f*) *Chronographs:* 1. 4-fold barrel-chronograph, each barrel to run 6 hours, driven by the same clock as the 15.06-inch equatorial. 2. Portable fillet chronograph by Siemens.

(*g*) *Clocks:* 1. Sidereal clock, quicksilver compensation by Frodsham. 2. Mean-time clock, quicksilver compensation by Molyneux. 3. Electric clock, outside dial and time gun.

(*h*) *Chronometers:* 1. Kullberg; mean time. 2. Farquhar; mean time. 3. J. Walker; mean time. 4. Frodsham; mean time 8-day. 5. Walker; sidereal (electric contact). 6. Walker; sidereal. 7. McLennan; $\frac{4}{10}$ seconds; pocket M. T.

(*i*) *Miscellaneous:* 1. Metre: A copy of the mètre des Conservatoire.

Froment. 2. Linear dividing engine by Froment. 3. Linear dividing engine by Elliott Brothers. 4. Photograph measuring machine by Grubb. 5. Balance by Oertling. 6. Five 2-meter and one 1¼-meter bars. Grubb. 7. Two comparator microscopes and long stone table. 8. 10-inch wheel cutting engine; Swiss. Jenssen & Hensen.

(*j*) 1. Sprengel pump 6 end on and many Geissler tubes. 2. Air-pump and apparatus.

(*k*) Various photographic apparatus.

(*l*) A large assortment of electrical and electro-magnetical apparatus. One standard and one marine barometer: Negretti & Zumbra. Various thermometers. 7-inch spherometer, 1 part $= \frac{1}{10000}$ inch, $\frac{1}{100000}$th by estimation; 4-inch spherometer; both by Hilger. Arithmometer by Thomas de Colmar; 6 places. Arithmometer by Thomas de Colmar; 10 places. Foucault siderostat by Eichens; 16-inch mirror (and a spare one), silver in glass, by A. Martin. Silbermann heliostat by Duboscq. Heliostat by Browning. King's barograph and anemograph by Casella. Binocular microscopes by Smith & Beck and Ross. Polariscope by Ladd; 10-inch, 6-inch, and 4-inch induction coils by Apps. A large collection of cut crystals; also diffraction apparatus by Schwerd.

The library is now getting to be very large and fairly representative. It is rich in early editions of astronomical and mathematical writers. The departments of periodicals and learned societies are good; the sections of optics and comets are fine. No opportunity of adding to the collection is missed. It has been found necessary lately to provide about 500 feet of additional shelving.

WORK DONE DURING THE PAST YEAR (1880):

The work during 1880 has been chiefly cometary and spectroscopic observations with the 15-inch refractor and determination of comparison stars with the transit circle; Mars was compared with *a Orionis* and *a Tauri* with the astrophotometer.

Some specimens of glass were tested with a spectrometer made from an old alt-azimuth instrument.

The greater part of the time has been devoted to the reduction of the observations connected with Lord Lindsay's Transit of Venus Expedition. These reductions are now approaching completion.

WORK PROPOSED FOR 1881:

The same class of work is proposed for 1881.

PUBLICATIONS:

No considerable works were published in 1880. Various papers were communicated to the "Astronomische Nachrichten"; Monthly Notices of the "Royal Astronomical Society," and "Urania," besides which 13 special circulars were distributed to all applicants.

DURHAM, *England.*

Observatory.

Longitude from Greenwich, 6m 19s.8 W.
Latitude, 54° 46′ 6″.2 N.
Directors: T. CHEVALLIER, 1840;
G. A. GOLDNER, 1872.

Founded by subscription in 1840. First observations made in 1842.

DÜSSELDORF, *Prussia.*

Sternwarte (formerly named Bilk).

Longitude from Greenwich, 27m 5s E.
Latitude, 51° 12′ 25″. N.

Authority for latitude and longitude: "Astronomische Nachrichten" 643, and "Berliner Jahrbuch."

Directors: J. F. BENZENBERG, 1809;
F. BRÜNNOW, 1848;
ROBERT LUTHER, 1855.

Established in 1809, by J. F. BENZENBERG, the savant, who in 1844 erected a more complete building at Bilk, 1¼ miles (two kilometers) south of the town. This establishment, liberally endowed by its founder, became the property of the town in 1847, and was enlarged by it in 1852. Nearly twenty of the minor planets have been discovered here.

INSTRUMENTS:

(*a*) An old repetition circle of one foot, by the late BAUMANN, at Stuttgart, giving 10″ of centesimal division.

(*b*) Meridian transit instrument made by the late EMIL SCHROEDTER, at Düsseldorf, objective from Munich, focal distance 2 feet, aperture 2 inches, little circle divided in half degrees, with nonius, one minute.

(*c*) New equatorial instrument, made by CHARLES BAMBERG, at Berlin, in use since September, 1877, objective by Dr. SIGMUND MERZ, at Munich, focal distance 7 feet, aperture 7 inches, magnifying powers of eyepieces 49 to 188. Stars of the 11.5 magnitude can be seen with it. Old reserve tube with horizontal and vertical motion, made by MERZ & SONS, at Munich, 1847, focal distance 6 feet, aperture 4⅓ inches. Stars of the 11.0 magnitude can be seen with it.

(*n*) Two old sidereal time clocks made by UTZSCHNEIDER & FRAUENHOFER, at Munich.

(*h*) One mean-time chronometer by KESSELS, at Altona, and a Swiss watch.

Some small instruments of minor importance.

OBSERVATIONS DURING THE PAST YEAR (1880):

Besides the determination of clock errors there have been made at this Observatory, during the year 1880, 50 observations of 18 minor planets, and since 1848, 993 observations of 128 minor planets, published in the "Astronomische Nachrichten."

WORK PROPOSED FOR THE COMING YEAR (1881):

It is intended to continue the observations and calculations of planets.

EDINBURG, *Scotland.*

Royal Observatory.

Longitude from Greenwich, 12m 43s.05 W.
Latitude, 55° 57′ 23″.2 N.
Directors: R. BLAIR, 1780;
T. HENDERSON, 1833;
C. P. SMYTH, 1846.

The old Observatory, founded by subscription in 1776, was not completed until 1792. No Observations were ever made there. The new observatory was projected in 1812, and erected on shares in 1818. The municipality donated the ground. In 1834, the founders ceded its administration to the State, and in 1846 made over the ownership. Time signals have been given there since 1855. Since 1872, the firing of a cannon has been substituted for the former ball.

ELSFLETH, *Germany.*

Observatorium der Navigations Schule.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: C. BEHRMANN, 1876.

FLORENCE, *Italy.*

1. *Osservatorio Astronomico;* 2. *Osservatorio del R. Museo.*

Longitude from Greenwich, 45m 1s.5 E.
Latitude, 43° 46′ 4″.1 N.
Directors: F. FONTANA, 1774;
D. DI VECCHI, 1807;
DEL RICCO, 1815; (?)
G. INGHIRAMI, 1818;
J. L. PONS, 1829;
G. B. AMICI, 1831;
G. B. DONATI, 1864;
W. TEMPEL, 1873.

The first Observatory here was established by the Jesuits at San Giorannino College, later called *The Religious Schools* (Scole Pie). A second was proposed by the government in 1774 as an annex to the Museum of Physics and Natural History of the Pitti Palace. It was built from 1777 to 1784, and afterwards the establishment was transferred to the hill of Arcetri, where GALILEO lived during the latter part of his life.

FRANKFURT A. M., *Prussia.*

Private Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: Dr. EPSTEIN.

GENEVA, *Switzerland.*

Observatoire de Genève.

Longitude from Greenwich, $24^m\ 36^s.77$ E.
Latitude, 46° 11′ 58″.8 N.
Directors: J. A. MELLET FAVRE, 1772;
M. A. PICTET TURRETIN, 1790;
J. F. T. MAURICE, 1794;
P. PICTET, 1802;
A. GAUTIER, 1819;
L. F. WARTMANN, 1832;
E. PLANTAMOUR, 1840.

Founded in 1771, completed in 1773. Octagonal structure built in great part at the expense of J. A. Mellet, upon a casemate of the Bastion Saint Antoine. In 1829 the representative council of the canton passed a resolution for the construction of a new Observatory to be built upon the same bastion not far from the old edifice. It is composed of a main building of one story, and of two lateral turrets with hemispheric domes.

GENOA, *Italy.*

Osservatorio della R. Università.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

GEORGETOWN, *British Guiana.*

Observatory.

Longitude from Greenwich, ——?
Latitude, ——?
Director: ——?

GLASGOW, *Scotland.*

Observatory.

Longitude from Greenwich, $17^m\ 10^s.6$ W.
Latitude, 55° 52′ 42″.8 N.
Directors: J. P. NICHOL, 1840;
R. GRANT, 1860.

Commenced in 1818 at the expense of a society. Permanently organized in 1840 with the help of a public subscription, of one subsidy from the University and another from the State. In 1862 a special hall was added for an equatorial, which has an aperture of 9 inches: ($0^m.23$.)

GOTHA, *Germany.*

Sternwarte.

Longitude from Greenwich, $42^m\ 50^s.53$ E.
Latitude, 50° 56′ 37″.5 N.
Directors: F. X. VON ZACH, 1787;
B. A. VON LINDENAU, 1808;
J. F. ENCKE, 1817;
P. A. HANSEN, 1825;
A. KRÜGER, 1875.

The first Observatory was erected in 1784 on the Seeberg (Lake Mountain) 1¼ miles (two kilometers) from the town. One of the first mural circles constructed to replace quadrants, made by RAMSDEN, was mounted here. In 1853 a new Observatory was built in the Jägerstrasse, not far from the ducal palace.

GÖTTINGEN, *Prussia.*

Königliche Sternwarte.

Longitude from Greenwich, $39^m\ 46^s.24$ E.
Latitude, 51° 31′ 47″.9 N.
Authority for latitude and longitude: "Berliner Yahrbuch."

Directors: J. A. VON SEGNER, 1735;
J. TOBIAS MAYER, 1754;
G. M. LORNITZ, 1762;
A. G. KÄSTNER, 1764;
K. F. VON SEYFFER, 1800;
C. F. GAUSS, 1807;
Dr. E. F. W. KLINKERFUES, 1856.

Assistant: D. HEIDORN, calculator.

Founded in 1734, at the same time with the University, and located in one of the round towers of the ancient fortification, around which was built an exterior gallery. In 1811 the Observatory was transferred to a more suitable spot outside the southern gate-way of the town. This new building is on the plan of a rectangle, with the longer sides facing east and west. An addition is made by wings to the north, a cupola surmounts the central vestibule, and a terrace encircles the whole structure. In 1818 the first meridian circle ever made and mounted in Europe was placed there. The maker was J. G. REPSOLD.

INSTRUMENTS:

(*a*) *Meridian circles:* one made by REPSOLD, sr., of Hamburg; diameter of circle, 3½ feet, divided to 5′; read by two microscopes to 1″; aperture of objective 4½ inches (114^{mm}); magnifying power ordinarily employed, 96 diameters: one made by REICHENBACH, of Munich; diameter of circle 3 feet; divided to 3′; read by four microscopes to 0.24″; aperture of objective 4¼ inches (109^{mm}); magnifying power ordinarily employed, 50 diameters.

(*b*) *Meridian transit instrument:* maker, REICHENBACH, of Munich; aperture, 4½ inches (116^{mm}); magnifying power, 75 diameters; (*b′*) one portable, maker, ERTEL, of Munich.

(*c*) *Equatorial instrument:* maker, FRAUENHOFER, of Munich; aperture of objective 2.9 inches (74^{mm}); magnifying power of eye-piece, 75. (*c′*) Five telescopes: makers, 1st, MERZ, of Munich; 6 feet long, aperture 5 inches; 2d, STEINHEIL, of Munich; 5 feet long, aperture 4 inches; 3d, DOLLOND, of Munich; 4 feet long, aperture 3½ inches; 4th, DOLLOND, of Munich; 3 feet long, aperture 3 inches; 5th, PLÖSSL, of Vienna; 28 inches long, aperture 2¼ inches. Three comet-seekers: makers, 1st, MERZ, of Munich; 6 inches aperture; 2d, MERZ, of Munich; 3 inches aperture; 3d, VOIGTLÄNDER, of Brunswick; 2½ inches aperture.

(*d*) *Spectroscope:* by MERZ, of Munich.

(*f*) *Chronograph:* by AUSFELD, of Gotha.

(*g*) *Clocks:* one mean time; maker, CASTENS; two sidereal: makers, 1st, HARDY, of London; 2d, SHELTON.

(*h*) *Chronometers:* four mean time; makers, 1st, BERTHOUD; 2d, SACKMANN; 3d and 4th, KNOBLICH; 5th, HARDY, sixtieth part of a second.

(*i*) *Miscellaneous:* heliometer by FRAUENHOFER, of Munich; theodolites, one by REICHENBACH, two by MEYERSTEIN; sextants by CARY,

TROUGHTON, PISTOR, STEINHEIL, and **BREITHAUPT**; two heliotropes by **MEYERSTEIN**.

OBSERVATIONS DURING THE PAST YEAR:

(*b*) Observations on planets and comets.

(*c*) Observations on comets with the six-foot refractor of **MERZ**.

PRINCIPAL PUBLICATION DURING PAST YEAR, 1880, 1881. Prof. Dr. **KLINKERFUES**: Tobias Mayer's grössere Mondkarte, nebst detailzeichnungen, 13 Karten, mit Text.

GREENWICH, *England*.

Royal Observatory.

Longitude from Washington, $5^h\ 8^m\ 12^s.09$ E.

Latitude, 51° 28′ 38″.4 N.

Authority for latitude and longitude: Nautical Almanac, Greenwich observations 1878.

Directors: J. **FLAMSTEED**, 1675;
E. **HALLEY**, 1720;
J. **BRADLEY**, 1742;
N. **BLISS**, 1762;
N. **MASKELYNE**, 1765;
J. **POND**, 1811;
Sir G. B. **AIRY**, K. C. B. (Astronomer Royal), 1835.

Chief assistant: W. H. M. **CHRISTIE**.

First-class assistants: **EDWIN DUNKIN**;
G. S. **CRISWICK**.

Second-class assistants: A. M. W. **DOWNING**;
E. W. **MAUNDER**;
W. G. **THACKERAY**;
And one vacancy.

Founded by royal statute on the 4th May, 1675. Built in the park at Greenwich by **CHRISTOPHER WREN**, architect. At first it consisted merely of an octagonal tower. In 1860 **FLAMSTEED** put up an additional wing to accommodate the mural sector, with the help of which he made his catalogue of stars. The board of visitors was created in 1710. In 1749 and the years immediately following great improvements and additions were made. The sector used by **BRADLEY** in discovering the phenomenon of aberration was transferred to Greenwich, and **BIRD** supplied a mural quadrant with a radius of 7 feet 10½ inches ($2^m.4$), besides remodeling the one made by **GRAHAM**. A statute of 1765 confirmed the right of supervision vested in the Royal Society and exercised by the board of visitors. In 1770 two revolving domes were constructed upon the turrets, and these have served as models for all revolving turrets since constructed. In 1772 the first achromatic object-glass ever used at Greenwich was attached to the south quadrant. It had an aperture of 2⅝ inches (68 millimeters). In 1779 the expediency of enlarging the meridian openings was acknowledged; hitherto the aperture had only been 6 inches ($0^m\ 15^s$).

At the beginning of the present century it became necessary to rebuild the Observatory, and the work, continuing until 1811, consisted in the construction of two rectangular buildings, the eastern one being the Observatory proper and containing halls for the meridian instruments, the library, and office, while the western structure was intended for the dwelling-house of the superintendent. It was in one of these new halls that the first model of a mural circle, 5 feet ($1^m.5$) in diameter, constructed by E. TROUGHTON, was placed in 1812.

The present organization of Greenwich Observatory dates from a royal statute of 1830. According to the terms of this statute the board of visitors consists of the members of the Royal Society, the members of the Astronomical Society, and the Oxford and Cambridge professors of astronomy. In 1844 the first alt-azimuth was set up. It was designed by AIRY, and made by RANSOME & MERZ and TROUGHTON & SIMMS, being intended for lunar observations.

As a finishing touch, the immense dome to the southeast was built in 1859 for the reception of the equatorial of W. SIMMS, with an object-glass, by G. MERZ, having a focal length of 34 feet 5 inches ($10^m.5$); now used for spectroscopic work.

The observations made annually at Greenwich have been published regularly since 1765. In the first volume of this publication we find the first notice of the illumination of the reticulation in a meridian instrument by means of the axis of the spy-glass.

INSTRUMENTS:

(*a*) *Meridian circle:* one; makers, RANSOMES & MAY (engineers), TROUGHTON & SIMMS (opticians); diameter of circle, 72 inches; divided to 5′; read by six microscopes to 0″.06; four supplementary microscopes for determination of division errors and occasional use: aperture of objective, 8.1 inches; for observations of the sun, aperture employed, 8.1; magnifying power ordinarily employed, 195 diameters.

(*b′*) *Alt-azimuth:* makers, RANSOMES & MAY and W. SIMMS; aperture, 4 inches. Magnifying power, 100; diameter of circles, 3 feet, divided to 5′.

(*c*) *Equatorial instruments:* makers, RANSOMES & SIMMS (engineers) TROUGHTON & SIMMS (opticians), MERZ (objective); aperture of objective, 12.8 inches; magnifying power of eye-pieces, 60 to 1500. (*c′*) *Sheapshank's equatorial:* makers, T. GRUBB, CAUCHOIX, (objective); aperture of objective, 6¾ inches. *Naylor equatorial:* maker, T. COOKE, of York; aperture, 6 inches. *Shuckburgh equatorial:* maker, RAMSDEN; aperture, 4.1 inches.

(*d*) *Spectroscopes:* half-prism spectroscope; maker, HILGER. Direct vision: one, two, or three compound "half prisms" with dispersions (A to H) of about 18½°, 83°, and 335°. *Single-prism stereoscope:* Makers, TROUGHTON & SIMMS; one flint prism.

(*e*) *Photometer:* AIRY'S double-image micrometer; makers, TROUGHTON & SIMMS.

(*f*) *Chronograph :* makers, E. DENT & Co.

(*g*) *Clocks:* one mean time; makers, SHEPHERD & SON: one sidereal; makers, E. DENT & Co., HARDY, ARNOLD, GRAHAM.

(*h*) *Chronometers:* mean time; makers, various. There are always on hand a large number rated for the navy; some of these are used when necessary for the Observatory. Sidereal; none of accurate character.

(*i*) *Miscellaneous :* Photoheliograph; maker, DALLMEYER; aperture of objective, 4 inches. Several portable telescopes; aperture, 4 inches to 2¾ inches. Five other 6-inch equatorials (packed in cases) returned from Transit of Venus Expedition, 1874. Five 3-inch portable transits by SIMMS; one 14-inch alt-azimuth by SIMMS; three 14-inch altitude instruments by SIMMS; four photoheliographs by DALLMEYER (all returned from the Transit of Venus Expeditions, 1874).

OBSERVATIONS DURING THE PAST YEAR AND WORK PROPOSED FOR THE COMING YEAR (1881):

On all the points mentioned here very full information will be found in the "Introduction to the Greenwich Observations" and in the "Astronomer Royal's Report to the Board of Visitors".

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR 1880:

The following are included in volume of Greenwich observations and also published separately: Greenwich observations for 1878, published in London (H. M. Stationery office), 884 pages; Astronomical results; Spectroscopic and photographic results; Magnetical and meteorological results; Introduction to Greenwich observations; Rates of chronometers on trial for purchase, 1879; Report of Astronomer Royal to board of visitors, 7 June, 1879; Spectroscopic and photographic results, 1879.

HALIFAX, *England.*

Bermerside Observatory, Skircoat.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

HAMBURG, *Germany.*

Sternwarte.

Longitude from Greenwich, $39^{m}\ 53^{s}.7$ E.
Latitude, 53° 33′ 7″ N.

Directors: MOSER, 1823;
K. L. C. RÜMKER, 1830;
Dr. GEORG F. W. RÜMKER, 1863.
Secretary: Dr. CARL SCHRADER.

Built by J. G. REPSOLD, in 1810, upon a location near the Altona gate; destroyed by the French in 1813; rebuilt in 1825, through a legacy left by GRELL, upon the site of the old ramparts, and still in the neighborhood of the Altona gate. It has a central hall for meridian instruments, and two wings surmounted by turrets. The east wing is used for a school of navigation.

HELSINGFORS, *Russia.*

Magnetnaia e Meteorologicheskaia Observatoria.

Longitude from Greenwich, 1h 39m 49s.16 E.
Latitude, 60° 9′ 43″.3 N.
Directors: F. W. A. ARGELANDER, 1829;
G. LUNDAHL, 1841;
F. WALDSTEDT, 1852;
A. KRÜGER, 1852.

Founded in 1829, near the University, after the fire at Abo had destroyed the scientific instruments of that Finnish town. It was at Helsingfors that ARGELANDER completed and published his famous catalogue of the proper motions of the stars. This Observatory is the most northerly in the world (latitude 60° 9′).

IPSWICH, *England.*

Orwell Park Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

JENA, *Saxe-Weimar.*

Sternwarte.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Directors: J. F. POSSELT, 1820;
L. SCHRÖN, 1852;
E. ABBE, 1878.

Built in 1820 in the same garden where SCHILLER wrote Wallenstein.

KALOCSA, *Hungary*.

Kalocsa Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

KARLSRUHE, *Baden*.

Sternwarte.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: W. VALENTINER.
Transferred from Mannheim in 1879.

KASAN, *Russia*.

Observatoria.

Longitude from Greenwich, $3^h\ 16^m\ 28^s.9$ E.
Latitude, 55° 47′ 24″.2 N.
Directors: J. J. LITTROW, 1814;
J. M. SIMONOFF, 1816;
M. LIAPUNOW (or LEPOUNOFF), 1846;
M. KOWALSKI, 1854.

Founded in 1814 by the University. Constructed upon a very solid, ancient structure; square tower, 23 feet (seven meters) in height. The southern gallery adjoins a wooden shed at its west angle, which has a movable roof. The building, with a portion of the instruments, was burned on the occasion of a fire which destroyed part of the town on the 5th September, 1842. Immediately restored.

KEW, *England*.

Kew Observatory.

Longitude from Greenwich, $1^m\ 15^s.1$ W.
Latitude, 51° 28′ 6″ N.
Director: ——— ?

KHARKOFF, *Russia.* (Charkow.)

Observatoria.

Longitude from Greenwich, 2h 24m 54s.7 E.
Latitude, 50° 0′ 10″.2 N.
Director: J. FEDORENKO.
Recently established.

KIEL, *Prussia.*

Königliche Sternwarte.

Longitude from Greenwich, 40m 35s.76 E.
Latitude, 54° 20′ 29″.7 N.
Directors: C. A. F. PETERS, 1873;
Prof. Dr. A. KRUEGER, 1880.

Founded in 1873 by the transfer of the Observatory from Altona. (See ALTONA.)

KIEW, *Russia.*

Observatoria.

Longitude from Greenwich, 2h 2m 0s.64 E.
Latitude, 50° 27′ 11″.1 N.
Directors: ——— FEADOROW, 1838;
A. SCHIDLOFFSKY, 1855;
M. K. LANDRICOFF, 1872.

Established in 1838 as an annex to the University.

KILMARNOCK, *Scotland.*

Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

KJÖBENHAVN, *Denmark.* (Copenhagen.)

Universitets Astronomiske Observatorium.

Longitude from Greenwich, 50m 19s.2 E.
Latitude, 55° 41′ 13″.6 N.
Directors: C. LUMBORG (Latin, *Longomontanus*), 1637;
T. BARTHOLIN, 1647;
O. ROEMER, 1681;

Peter I. Horrebow, 1714;
C. Horrebow, 1753;
T. Bugge, 1777;
H. C. Schumacher, 1815;
Von Caroc, 1822;
C. F. R. Olufsen, 1832;
H. d'Arrest, 1856;
T. N. Thiele, 1876.
Assistants: **Schjellerup**;
Pechüle.

Founded in 1637, but only completed in 1656. The first edifice was destroyed by fire the 20th of October, 1728. The Observatory was re-established in the round tower belonging to the University. In 1820 a wooden addition was made to it on the Holken bastion. Finally, in 1857, it was reorganized and removed to the glacis of the fortress between the citadel and the *Osterthor* (eastern gate).

KÖNIGSBERG, *Prussia.*

Universitäts Sternwarte.

Longitude from Greenwich, $1^h\ 21^m\ 58^s.91$ E.
Latitude, 54° 42′ 50″.6 N.

Directors: **Z. W. Bessel**, 1811;
A. L. Busch, 1849;
M. L. G. Wichmann, 1866;
Prof. **E. Luther**, 1860.

Constructed in 1811 on one of the most elevated points of the ramparts to the northwest of the town. A main building divided into two great halls—a northern and a southern. Two wings—one the meridian hall, the other an addition. With the use of a meridian circle, made by **Reichenbach** and **Ertel**, 0^m 97 in diameter, **Bessel** and his assistants accomplished the work known as the "Königsberg Zones," giving the exact positions of 62,000 stars between the parallels of — 15° and + 45°.

This great undertaking was begun 19th August, 1821, and finished January 21, 1833.

KRAKAU, *Austria.* (Cracow.)

K. K. Sternwarte.

Longitude from Greenwich, $1^h\ 19^m\ 50^s.5$ E.
Latitude, 50° 3′ 50″ N.

Directors: **J. J. von Littrow**, 1807;
J. Leski, 1811;
M. Weisse, 1825;
Prof. Dr. **Francis M. Karlinsky**, 1864.

Assistants: Dr. DANIEL WIERZBICKI;
JOHN RALSKI.

Established in 1807 as an annex to the University. Turned into a powder magazine by the French in 1809. Set up once more on a spot a little to the north of the first building.

KREMSMÜNSTER, *Austria.*

Sternwarte.

Longitude from Greenwich, $56^m\ 32^s.2$ E.
Latitude, 48° 3′ 23″. 7 N.
Directors: A. DESING, 1748;
P. FIXLMILLNER, 1761;
T. DERFFLINGER, 1791;
B. SCHWARZENBRUNNER, 1824;
M. KOLLER, 1830;
A. RESLHUBER, 1847;
G. STRESSER, 1875.

Founded in the convent of the Benedictines in 1748; built in the convent garden at the northern extremity of the buildings. The Observatory consists of a massive tower, eight stories high, with two wings of five stories.

KRONSHTADT, *Russia.* (Cronstadt.)

Morskaia Astronomicheskaia Observatoria.

Longitude from Greenwich, ———?
Latitude, ———?
Directors: V. FUSS, 1840;
A. F. GRIGORIEFF.
Assistant: P. S. SHUBIN.
Observatory of the school of pilots. Founded about 1840.

LEIPZIG, *Saxony.*

Universitäts Sternwarte.

Longitude from Greenwich, $49^m\ 34^s.02$ E.
Latitude, 51° 20′ 6″. 3 N.
Directors: C. F. RÜDIGER, 1794;
K. B. MOLLIVERDE, 1811;
A. F. MOEBIUS, 1816;
G. A. JAHN, 1845;
C. C. BRUHNS, 1860.

Constructed, from 1787 to 1794, upon the great tower of the castle of Pleissenburg. A new Observatory, situated at the extreme end of one of the suburbs, took the place of the old one in 1861.

LEMBERG, *Austria.*

Observatory of the University

LEYDEN, *Holland.*

Rijks Observatorium.

Longitude from Greenwich, $17^m\ 56^s.35$ E.
Latitude, 52° 9′ 20″ N.
Directors: J. GOLIUS, 1632;
S. C. KECHEL, 1667;
C. MELDER, 1668;
B. DE VOLDER, 1682;
L. ZUMBACH DE KOESFELD, 1705;
W. J. S'GRAVESRUDE, 1717;
J. LULOFS, 1742;
D. VAN DE WIJNPRESSE, 1768;
P. NIEUWLAND, 1794;
J. A. FAS, 1797;
J. F. VAN BEEK-CALKOEN, 1799;
C. E. KAMA, 1812;
F. KAISER, 1837;
H. G. VAN DE LANDE BAKHUIJZEN, 1872.

Founded in 1632. The most ancient of existing Observatories in Europe. Originally built, as a great tower for the town clock, 1636. Enlarged in 1689. Repaired in 1817. In 1858 a new Observatory was commenced, and completed in 1860.

LEYTON, *Essex, England.*

Barclay Observatory.

Longitude from Greenwich, $0^s.87$ W.
Latitude, 51° 34′ 34″.
Authority for latitude and longitude, Ordnance Survey.
Director: CHARLES GEORGE TALMAGE, F. R. A. S.

INSTRUMENTS:

(*a*) *Meridian circles:* makers, HOUGHTON and SIMMS; diameter of circles, 36 inches, divided to 5′; read by 4 microscopes to 0″.1; aperture of objective, 4 inches; for observations of the sun aperture employed, 4 inches; magnifying power ordinarily employed, 80 diameters.

(*c*) *Equatorial instrument:* maker, COOKE, York; aperture of objective, 10 inches; magnifying power of eye-pieces, 70 to 1200.

(*g*) *Clock:* sidereal; maker, SIMMONDS, London.

OBSERVATIONS DURING THE PAST YEAR (1880):

(*a*) *Clock stars.*

(*c*) Measures of binary stars, comets, eclipses, occultations, and satellite phenomena.

WORK PROPOSED FOR THE COMING YEAR (1881):

Satellites of Saturn, binary stars, comets, and occultations.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR 1878:

C. G. TALMAGE, Leyton Astronomical Observations, vol. 4, London, 127 pp.

ADDITIONAL INFORMATION:

The Observatory is provided with double ——— and ring micrometers, with an extra 3-inch telescope, and a small transit instrument.

LISBON, *Portugal.*

Observatorio Astronomico da Tapada de Alcantara.

Longitude from Greenwich, $36^m\ 44^s.68$ W.
Latitude, 38° 42′ 31″.3 N.
Directors: G. B. CARBONE, 1722;
M. DO ESPIRITO-SANTO LIMPO, 17—;
P. J. M. CIERRA, 1806;
M. V. DO CONTO, 1823;
F. DA SILVEIRA, ——;
T. A. DOM, 1876.

Established at the Jesuits' College, 1722; adopted by the state in 1758. A new Observatory was built in 1857.

LISBON, *Portugal.*

Observatorio Astronomico na Escola Polytecnica.

Longitude from Greenwich, ———?
Latitude, ———?
Director: ———?
For the instruction of students only.

LISBON, *Portugal.*

Observatorio de Marinha.

Longitude from Greenwich, $36^m\ 25^s$ W.
Latitude, 38° 42′ 17″.6 N.
Director: FRANCISCO DE PAULA FERREIRA DE MESQUITA.
Established in 1798.

LIVERPOOL, *England.*

Observatory.

Longitude from Greenwich, $12^m\ 17^s.2$ W.
Latitude, 53° 24′ 4″ N.
Director: J. HARTNUP, 1845.

Founded in 1838 by the municipal council; completed in 1848. Transferred to Birkenhead, on the opposite bank of the Mersey, in 1867. It is provided with an apartment for the examination of chronometers, where the temperature can be raised by means of a gas heater. The equatorial is moved by clock-work, set in motion by hydraulic power. The time-signal is given to the shipping by firing a cannon.

LONDON, *England.*

Private Observatory.

Longitude from Greenwich, ———?
Latitude, ———?
Director: MR. GEORGE BISHOP. (Now discontinued.)

LONDON, *England.*

Tulse Hill Observatory [*Upper Tulse Hill, London,* S. W.].

Longitude from Greenwich, $27^s.7$ W.
Latitude, 51° 26′ 47″ N.
Director: ———?
Founded, 1856. Altitude, 170 feet above level of the sea.

INSTRUMENTS:

An equatorial instrument by GRUBB, of Dublin, so constructed that either a refractor of 15 inches aperture and 15 feet focal length, or a CASSEGRAIN reflector with metallic speculum of 18 inches aperture may be placed at pleasure on the same equatorial mounting, so that with either instrument the circles read sufficiently for the finding of objects. The driving-clock has, in addition to the usual governor balls, a secondary control of a pendulum in electrical connection with a standard clock.

Up to 1870, when the present equatorial was erected, a transit circle of 3½ inches aperture was mounted in the Observatory. At that time the principal instrument the Observatory contained was an 8-inch refractor by ALVAN CLARK, mounted equatorially by COOKE, of York.

There is a fine sidereal clock by ARNOLD, and various spectroscopes for use with the telescopes on the sun and stars; and there has been recently added a spectroscope with Iceland spar prism and quartz lenses for photography of spectra of stars.

Underneath the Observatory are two rooms, one devoted to chemistry and photography, the other to physical experiments in connection with spectrum analysis.

WORK IN 1880:

Continuation and completion of a series of photographs of spectra of various stars. Researches in connection with these spectra.

(See Philosophical Transactions of Royal Society of London, 1880, Part I, p. 669.)

LÜBECK, *Germany*.

Sternwarte.

Longitude from Greenwich, 42^m 45^s.55 E.
Latitude, 53° 51′ 31″.2 N.
Director: ———?

LUND, *Sweden*.

Lund Observatory.

Longitude from Greenwich, 52^m 45^s.02 E.
Latitude, 55° 41′ 52″.05 N.

Authority for latitude and longitude: Undersökning af Meridian cirkeln pŭ Lunds Observatorium jemte beståmmìng af dentammas folhöjd af AND. LINDSTEDT. Bestimmung der Längen-Differenz zwischen Berlin und Lund, auf telegraphischem Wege ausgeführt im Jahre 1868. Herausgegeben von C. Bruhns.

Directors: ——— ———;
A. LIDTGREEN, 1786;
——— ———, 1815;
J. M. AGARDT, 1847;
AXEL MÖLLER, *professor of astronomy.*
Assistants: N. C. DUNÉR, *observer;*
F. ENGSTRÖM, *cand. phil.*

Founded as a dependency of the University about 1760. Reorganized in 1866.

INSTRUMENTS:

(*a*) *Meridian circle:* one; makers, A. & G. REPSOLD, in Hamburg; diameter of circles, 39 inches (1 meter); divided to 2′; read by 4 microscopes to 0.1″; aperture of objective, 6½ inches (163^{mm}); magnifying power ordinarily employed, 173 diameters.

(*c*) *Equatorial instruments:* makers, G. & S. MERZ, in Munich, and E. JÜNGER, in Copenhagen; aperture of objective, 9½ inches (245^{mm}); magnifying powers of eye-pieces, 80 to 1,300 diameters. (*c'*) Makers, A. STEINHEIL, in Munich, and E. JÜNGER, in Copenhagen; aperture of objective, 4¼ inches (108^{mm}); magnifying powers of eye-pieces, 16 to 200 diameters.

(*d*) *Universal spectroscope* by G. & S. MERZ, in Munich, with 3 sets of prisms *à vision directe.* (*d'*) *Simple spectroscope* by HEUSTREU, in Kiel, constructed after the indication of Professor VOGEL, in Potsdam.

(*f*) *Chronograph:* one by MAYER & WOLF, in Vienna.

(*g*) *Clocks:* sidereal time; one, maker, KESSELS, in Altona: one, maker, TIEDE, in Berlin.

(*h*) *Chronometer:* mean time; maker, KESSELS, in Altona.

(*i*) One universal instrument by REPSOLD, in Hamburg; 3 telescopes by DOLLOND, MERZ, and PLÖSSL.

OBSERVATIONS DURING THE PAST YEAR (1880)

(*a*) 11,859 positions of stars in the zone 34° 50′ to 40° 10′ of north declination.

(*c*) (*c'*) Measures of double stars; observations of comets; observations of variable stars.

(*d*) (*d'*) Spectroscopical researches on red stars.

WORK PROPOSED FOR THE COMING YEAR (1881):

The same as in 1880.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR:

AXEL MÖLLER: Ephemeride für Fayes Comet, published in the Berliner Jahrbuch, 1882.

AXEL MÖLLER: Ephemeride für Pandora, published in the Berliner Jahrbuch, 1882.

N. C. DUNÉR: Ephemeride für Panopela, published in the Berliner Jahrbuch, 1882.

LYON, *France.*

Astronomical and Meteorological Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: C. ANDRÉ, 1877;
M. ANDRÉ;
Assistant: M. GONNESSIAT.

There was an Observatory in existence in the eighteenth century at the Jesuit College, where Fathers BONNET, BÉRAULD, LEFÈVRE, and LAPON made observations. The new Observatory was founded in 1877.

INSTRUMENTS:

(*a*) *Meridian circle:* maker, EICHENS; diameter of circles, 23½ inches (0^{m}.60), divided to 5′; read by 4 microscopes to 0″.1; aperture of objective, 6 inches; for observations of the sun, aperture employed, 6 inches; magnifying power ordinarily employed, 300 diameters.

(*b*) *Meridian transit instrument:* maker, RIGAUT; aperture, 2 inches; magnifying power, 150 diameters.

(*g*) *Clocks:* two sidereal; makers, BRÉGUET & RÉDIER, Paris.

(*h*) *Chronometers:* mean time; makers BRÉGUET, Paris: sidereal; maker, BRÉGUET, Paris.

WORK PROPOSED FOR THE COMING YEAR (1881):

The meridian circle is to be employed for zône observations.

MADRAS, *India.*

Madras Observatory.

Longitude from Greenwich, $5^h\ 20^m\ 58^s.4$ E.
Latitude, 13° 4′ 8″.1 N.
Directors: J. GOLDINGHAM, 1787.
——— WARREN (intermediate), 1805;
J. GOLDINGHAM, 1811;
S. G. TAYLOR, 1830;
W. S. JACOB, 1848;
——— WORSTER (intermediate), 1854;
W. S. JACOB, 1855;
J. F. TENNENT, 1860;
N. R. POGSON, 1860.

Founded in 1787 by the East India Company.

MADRID, *Spain.*

Observatorio de Madrid.

Longitude from Greenwich, $14^m\ 45^s.4$ W.
Latitude, 40° 24′ 30″.N.
Directors: J. CARONADO, 1790;
J. RODRIGUEZ, 1817;
——— BAVIA, 1821;
D. FONTAN, 1835;
PALO MARUZ, 1850;
A. AGUILAR, 1860;

Established at Buen Retiro in 1790. When the French occupied Madrid in 1808, they set up a battery at that place and the instruments were destroyed by a fire. The Observatory then abandoned was not restored until 1846. In 1852 the grounds were enlarged, and a pavilion with a revolving turret was erected.

MANILA, *Philippine Islands.*

Observatorio del Ateneo Municipal.

Longitude from Greenwich, ———?
Latitude, 14° 35′ S.
Directors: J. VERNACAI, 1804;
P. F. FAURA, —— (?).

Temporary installation in 1804. The institution became permanent about 1824.

MANNHEIM, *Baden.*

Grossherzogliche Sternwarte.

Longitude from Greenwich, 35^{m} $50^{s}.52$ E.
Latitude, 49° 29′ 11″ N.
Directors: C. MARGER, 1764;
K. J. KÖNIG, 1783;
J. N. FISCHER, 1786;
P. UNGESCHICK, 1788;
R. BARRY, 1788;
H. C. SCHUMACHER, 1813;
F. B. G. NICOLAI, ——;
A. M. NELLE, 1852;
E. SCHÖNFELD, 1859;
W. VALENTINER, 1875.

First established in the Electoral Castle of Schroetzingen, 6¼ miles (ten kilometers) from Mannheim, and in 1772 removed to the west of the town, where it was located in a tower 105 feet (32 meters) in diameter, with remarkably thick walls. In operation from 1794 to 1801. Transferred recently to KARLSRUHE. (See *Karlsruhe.*)

MARBURG, *Germany.*

Sternwarte.

Longitude from Greenwich, 35^{m} 5^{s} E.
Latitude, 50° 48′ 46″.9 N.
Director: ———?

MARSEILLE, *France.*

Observatoire.

Longitude from Greenwich, 21^{m} $34^{s}.64$ E.
Latitude, 43° 18′ 19″.1 N.
Directors: A. F. LAVAL, 1702;

E. PERENAS, 1728;
G. SAINT JACQUES DE SILVABELLE, 1764;
J. J. C. SHULIS, 1793;
——— BLANPAISE, 1811;
J. F. A. GAMBART, 1822;
B. VALZ, 1835;
E. STEPHAN, 1868.

The Society of Jesus had an Observatory at their College of Sainte Croix, founded 1702. In 1749 this scientific institution was taken in hand by the Ministry of Marine. It is a three-story building, longest from east to west, erected on the summit of the *Butte des Moulins*. In 1797 this Observatory was repaired. A new establishment was erected in 1869 on the hill of Longchamps, to supplement the work at the Paris Observatory. The instruments are distributed in separate apartments.

MELBOURNE, *Victoria*.

Melbourne Observatory.

Longitude from Greenwich 9h 39m 54s.8 E.
Latitude, 37° 49′ 53″.3 S.
Director: R. L. J. ELLERY, F. R. S., F. R. A. S.

Proposed first in 1853, and established, to begin with, at Williamstown Transferred to Melbourne in 1861. Building completed in 1863. In 1870 there was mounted, in a building set apart for the purpose, GRUBB'S great Cassegrain Reflector, with a focal length of 28 feet (8m.54), and an aperture of 4 feet (1m.22).

MENDON (*Paris*), *France*.

Observatoire.

Longitude from Greenwich, ———?
Latitude, ———?
Director: J. JANSSEN, 1875.

Observatory of Physical Astronomy in the park at Mendon. Instruments mounted in temporary buildings in 1875. There are photographs of the sun taken regularly at this place.

MEXICO, *Mexico*.

Observatory.

Longitude from Greenwich, 6h 36m 26s.67 W.
Latitude, 19° 26′ 1″.3 N.
Director: F. JIMENEZ.

Founded in 1877 at 19° 26′ north latitude.

MILANO, *Italy.*

R. Osservatorio Astronomico di Brera.

Longitude from Greenwich $36^m\ 45^s.97$ E.
Latitude 45° 27′ 59″ .2 N.
Directors: L. LAGRANGE, 1763;
F. REGGIO, 1777;
B. ORIANI, 1804;
F. CARLINI, 1833;
G. V. SCHIAPARELLI, 1862.

In 1760 a telescope of 33 feet (10 meters) focal distance was mounted in the College of the Brera by P. BOVIO and D. GERRA. The Observatory proper was founded in 1763. In the beginning it consisted of an octagonal structure to which, in 1775, two side towers were added. This Observatory has published its Ephemeris for one hundred years, 1775 to 1874.

MODENA, *Italy.*

Osservatorio.

Longitude from Greenwich $43^m\ 42^s.8$ E.
Latitude, 44° 38′ 52″.8 N.
Director: ——— ?

MONTCALIERI, *Italy.*

Osservatorio del R. Collegio C. Alberto.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

MONTSOURIS (*Paris*), *France.*

Observatoire de Montsouris.

Longitude from Greenwich, $9^m\ 20^s.68$ E.
Latitude, 48° 49′ 18″ N.
Directors: E. MOUCHEZ, 1875.
DR. MARIÉ DAVY.
Assistant: ALFRED DE VAULABELLE.

Founded in 1875 as an Observatory for students by the Department of the Marine, in the southwest corner of the Park of Montsouris at the southern extremity of Paris.

MOSCOW, *Russia.*

Observatory of the Imperial University.

Longitude from Greenwich, 2h 30m 16s.9 E.
Latitude, 55° 45′ 19″.8 N.
Authority for latitude and longitude: Nautical Almanac.

Directors: ——— KRASSILUSKOW, 1750;
C. F. GOLDBACH, 1804;
——— FISCHER, 1861;
D. PEREVOTSCHIKOFF, 1824;
A. DRASCHNOSOFF, 18—;
K. S. SCHWEIZER, 1856;
Prof. Dr. THEODORE BREDICHIN, 1876.

Assistants: W. CERASKI;
A. BELOPOLSKY;
A. SOCALOFF.

Founded in 1753 as an annex to the University. A new building was put up in 1804 in Bielogorod.

INSTRUMENTS:

(*a*) *Meridian circle:* one; maker, REPSOLD, in Hamburg; diameter of circle, 36 inches; divided to 2′; read by 4 microscopes to 0.1″; aperture of objective, 5.3 inches; magnifying power ordinarily employed, 100 diameters.

(*c*) *Equatorial instrument:* maker, MERZ, in Munich; aperture of objective, 10.7 inches; magnifying power of eye-pieces, 100 to 1200. (*c*′) Photoheliograph of DALMAYER, in London.

(*d*) Universal spectroscope of MERZ, in Munich; direct vision with 10 prisms and micrometer.

(*e*) One photometer of ZÖLLNER.

(*f*) *Chronograph:* of SIEMENS and HALSKE.

(*g*) *Clocks:* mean time, two; makers, TIEDE, UTZSCHNEIDER: sidereal, two; makes, KESSELS, TOLSTOI.

(*h*) *Chronometers:* mean time, two; maker, DENT: sidereal, two; makers, DENT, KESSELS.

(*i*) *Miscellaneous:* transportable transit instruments, theodolites, universal instruments, &c.

OBSERVATIONS DURING THE PAST YEAR (March to December, 1880):

(*a*) Small planets.
(*c*) Comets; Jupiter; spectroscopic observations of the sun.
(*d*) Sun and comets.
(*e*) Photometrical observations of stars.
(*i*) The practical instruction of the students of the University.

WORK PROPOSED FOR THE COMING YEAR (1881):

The same as in the year 1880, and the investigation of the gravity at Moscow with the reversion pendulum constructed by REPSOLD.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEARS 1874–1880:

Professor BREDICHIN, "Annales de l'Observatoire de Moscow," vols. I, II (parts 1 and 2), III (parts 1 and 2), IV (parts 1 and 2), V (parts 1 and 2), VI (parts 1 and 2), VII (part 1).

ADDITIONAL INFORMATION:

The clock-work of the equatorial is out of use, and generally the means of the Observatory for scientific works and for their publications are very insufficient.

MÜNCHEN, *Bavaria*.

Königliche Sternwarte.

Longitude from Greenwich, 46m 26s.13 E.
Latitude, 48° 8′ 45″.5 N.
Directors: K. F. VON SEYFFER, 1809;
J. VON SOLDNER, 1823;
J. VON LAMONT, 1834 (1).

Founded in 1809, on the hill of Bogenhausen, near Munich. A main building of one story, facing east and west; two wings extend toward the north. An edifice designed for the purpose was put up in the garden for a great refractor, by the aid of which LAMONT made his observations of the satellites of Saturn and of the nebulæ.

MUNICH, *Bavaria*.

See *München*.

MÜNSTER, *Prussia*.

Sternwarte.

Longitude from Greenwich, ——?
Latitude, ——?
Director: E. HEIS, 1852.

Founded in 1852, in the neighborhood of the Academy (High School). It was here that HEIS pursued his extended researches into the nature of shooting stars, the zodiacal light, and uranometry.

NAPLES, *Italy*.

See *Napoli*.

NAPOLI, *Italy.*

R. Osservatorio, Capo di Monte.

Longitude from Greenwich, $57^m\ 0^s.9$ E.
Latitude, 40° 51′ 45″.4 N.
Directors: G. CASELLA, 1791;
F. M. DA PRADO, 1808;
F. TUCCARI, 1812;
C. BRIOSCHI, 1818;
E. CAPOCCI, 1833;
——— DEL RE, 1849;
A. DE GASPARIS, 1864.

Proposed in 1788. The buildings begun at the northeast corner of the Palace of the Library (Palazzo della Biblioteca) and Royal Museum (Museo Reale) were left incomplete in 1790. In 1809 one of the towers of the old Convent of San Gandisso was appropriated to this object. In 1812 was laid the first stone of a new Observatory on the hill of Miradois, at the point called *Capo di Monte.* The instruments were mounted in 1819. Seven asteroids have been discovered at this Observatory.

NEUCHATEL, *Switzerland.*

Observatoire Cantonale.

Longitude from Greenwich, $27^m\ 50^s.2$ E.
Latitude, 46° 59′ 51″ N.
Director: A HIRSCH, 1858.

Founded in 1857. A rectangular structure of 88½ feet by 26¼ feet (27 by 8 meters), and 19½ feet (6 meters) in height; a tower with a revolving turret.

NICOLAIEV, *Russia.*

Nicoloevskaia Observatoria.

Longitude from Greenwich, $2^h\ 7^m\ 54^s.1$ E.
Latitude, 46° 58′ 20″.6 N.

Authority for latitude and longitude: for latitude, K. KNORRE, "Astron. Nachr.," vii, 261; for longitude, telegraphic determination of 1877, not yet published.

Directors: K. F. KNORRE, 1821;
J. KORTAZZI, 18—.

Founded in 1821; completed in 1826.

INSTRUMENTS:

(*a*) *Meridian circle:* maker, ERTEL, in Munich; diameter of circle, 38 inches; divided to 3′; read by four microscopes to 1″; aperture of objective, 4.2 inches; magnifying power ordinarily employed, 100 diameters.

(*c*) *Equatorial instrument:* makers, REPSOLD & SONS, in Hamburg; aperture of objective, 9½ inches; magnifying powers of eye-pieces, 100, 150, 330, 476, 666.

(*f*) *Chronograph:* one of HERBST, in Pulkowa.

(*g*) *Clocks:* one mean time; maker, KESSELS, No. 1282: one sidereal; makers, BARRAUD, No. 769, and HOHVIN, No. 24.

(*h*) *Chronometers:* mean time, 89, of different makers: sidereal, 3, of different makers.

(*i*) *Miscellaneous:* one transportable transit instrument of HERBST, in Pulkowa, for the determination of time in the vertical of Polaris; aperture, 2.7 inches; magnifying power, 100.

(*k*) One transportable verticle circle, 11 inches; aperture, 1.9 inches; circle divided to 4′; read by 2 microscopes to 2″.

OBSERVATIONS DURING THE PAST YEAR:

(*c*) Comets, Schaberle, Hartwig, Faye; Jupiter's satellites and spots.

(*i*) Determinations of clock corrections for the investigation of the rates of the naval chronometers. Determination of the coefficients of compensation of the chronometers.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR 1880:

T. KORTAZZI: Beobachtungen des Comet 1880 C., published in the "Astronomische Nachrichten," vol. 97, p. 335.

T. KORTAZZI: Sur les taches de Jupiter, published in the "Bulletin de l'Académie Impériale de St.-Petersbourg."

T. KORTAZZI: Tables of W. THOMSON for the facilitation of Sumner's method at sea, edited in an altered form (Russian).

NOTTINGHAM, *England.*

Alexandria Park Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

ODESSA, *Russia.*

Sternwarte.

Longitude from Greenwich, $2^h\ 3^m\ 2^s.3$ E.
Latitude, 46° 28′ 36″ N.
Director: ——— ?

OFEN, *Austria-Hungary.*

(Budapesth) Sternwarte.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Directors: J. PASGNICH, 1804;
P. TITTEL, 1824;
——— ———, 1831;
L. MAYER, 1860 (?).
Founded upon the "Blocksberg" in 1803.

O-GYALLA, *Hungary.*

Astro-Physikalisches Observatorium.

Longitude from Greenwich, $1^h\ 12^m\ 45^s.59$ E.
Latitude, 47° 52′ 43″.4 N.
Director: ——— ?

OLMÜTZ, *Austria.*

Sternwarte.

Longitude from Greenwich, $1^h\ 9^m\ 2^s.6$ E.
Latitude, 49° 35′ 43″ N.
Director: ——— ?

OXFORD, *England.*

Oxford University Observatory.

Longitude from Greenwich, $5^m\ 0^s.4$ W.
Latitude, 51° 45′ 34″.2 N.
Director: O. PRITCHARD, 1873.
Founded in 1873.

OXFORD, *England.*

Radcliffe Observatory.

Longitude from Greenwich, $5^m\ 2^s.6$ W.
Latitude, 51° 45′ 36″ N.
Directors: T. HORNSBY, 1771;
A. ROBERTSON, 1810;

S. P. RIGAUD, 1827;
M. J. JOHNSON, 1839;
R. MAIN, 1860;
E. J. STONE, 1878.

Founded in 1772, with the help of a legacy from RADCLIFFE. The ground was donated by the Duke of Marlborough. Time has been noted by means of a chronograph since 1858.

PADOVA, *Italy*.

Osservatorio Astronomico dell' Università.

Longitude from Greenwich, 47m 29s.13 E.
Latitude, 45° 24′ 2″.5 N.
Directors: G. TOALDO, 1761;
V. CHIMINELLO, 1797;
G. SANTINI, 1813;
G. LORENZONI, 1877.

Founded in 1761 by the Venetian senate, and accommodated in a massive tower built in the thirteenth century by the tyrant Ezzelino for a state prison.

PADUA, *Italy*.

See *Padova*.

PALERMO, *Italy*.

R. Osservatorio.

Longitude from Greenwich, 53m 25s E.
Latitude, 38° 6′ 44″ N.
Directors: G. PIAZZI, 1787;
N. CACCIATORE, 1817;
G. CACCIATORE, 1842;
D. RAGONA, 1858;
G. CACCIATORE, 1860.

Proposed in 1786. Established in the Saint Ninfa tower of the Royal Palace, the ancient residence of the Emirs during the Arabian dominion. The first complete vertical circle made by Ramsden, and finished in 1789, was mounted in this Observatory. PIAZZI used it from 1792 to 1813, for the observations which served him as a basis for his famous catalogue. Ceres was discovered at Palermo on the first day of the nineteenth century.

Paramatta, *New South Wales.*

Paramatta Observatory. (See *Sydney.*)

Longitude from Greenwich, $10^h\ 4^m\ 6^s.2$ E.
Latitude, 33° 48′ 49″.8 N.
Director: ———?

Paris, *France.*

Observatoire Nationale.

Longitude from Greenwich, $9^m\ 21^s.02$ E.
Latitude, 48° 50′ 11″.8 N.
Directors: J. D. Cassini, 1671;
J. Cassini, 1712;
C. F. Cassini (de Thury), 1756;
J. D. Cassini (de Thury), 1784;
J. J. L. de La Lande, 1795;
P. Méchrin, 1801;
A. Brunard, 1804;
D. F. J. Arago, 1811;
U. J. J. Le Verrier, 1853;
C. E. Delaunay, 1871;
U. J. J. Le Verrier, 1872;
E. Mouchez, 1878.

National Observatory (formerly Royal, since Imperial) built in 1667 under the auspices of the Academy of Sciences, according to plans of C. Perrault. A vast central hall; two towers, east and west. In 1732, a small room to accommodate a mural quadrant was added beyond the eastern tower, and in 1742 this was extended by a second enclosure for a moveable quadrant. In 1760 a turret with a revolving roof was built to the south of this addition. The main building having become dilapidated was restored in 1786—completed 1793—since when it has been detached and the south terrace built. In 1832 the small rooms where observations are taken were repaired, and the amphitheater and a rotunda with a revolving roof built upon the principal terrace. The dome intended for the shelter of the great equatorial was placed on the summit of the building in 1850. The great telescope with a mirror of silvered glass—4 feet ($1^m.2$) in diameter—was mounted in 1876, in a building on the ground-floor level. John Dominic Cassini discovered four of the satellites of Saturn at the Paris Observatory, and also first investigated the subject of the Zodiacal Light, and here, too, the great grandson of this astronomer was the first to follow the variations of the magnetic needle with minute and persevering industry; and it was here that **Arago** and **Mathieu** demonstrated the extremely small parallax of the stars.

A large number of astronomical manuscripts, containing matter of great interest, are preserved at the Paris Observatory.

PARMA, *Italy.*

R. Osservatorio Astronomico.

Longitude from Greenwich, ——— ?
Latitude, ———?
Director: ———.?

PARSONSTOWN, *Ireland.*

Lord Rosse's Observatory.

See *Birr Castle.*

POLA, *Austria.*

Naval Observatory.

Longitude from Greenwich, $55^m\ 23^s.18$ E.
Latitude, 44° 51′ 49″ N.
Director: J. **Palisa**, 1872.

Founded in 1872. More than a dozen minor planets have been discovered here.

PORT LOUIS, *Mauritius.*

Observatory.

Longitude from Greenwich, ———?
Latitude, ———?
Director: ———?

POTSDAM, *Prussia.*

Astro-Physikalisches Institut.

Longitude from Greenwich, $52^m\ 17^s$ E
Latitude, 52° 22′ 56″ N.
Director:——— ?
Observers: **Sporer**, **Vogel**, and **Lohse**.

Built upon a hill adjoining the Park at Potsdam. Opened in 1879 under the auspices of the Astronomische Gesellschaft.

POULKOVO, *Russia.*

Nicolaevskaia Glavnaia Observatoria.

Longitude from Greenwich, $2^h\ 1^m\ 18^s.67$ E.
Latitude, 59° 46′ 18″.7 N.
Directors: F. W. G. VON STRUVE, 1834;
O. VON STRUVE, 1864.

Founded in 1834. Three principal halls on the ground floor, the eastern one being used for the meridian circle, the western one for the meridian telescope, and the southern one occupied by the prime vertical. Three revolving domes, the central and largest containing MERZ and MAHLER'S Refractor, which has a focus of 23¼ feet ($7^m.1$) and an aperture of 15½ inches ($0^m.40$). A very rich astronomical library. The most elaborate and minute researches on the minor corrections of spherical astronomy, notably the corrections of aberration of nutation and precession, have been made chiefly at this Observatory.

PRAGUE, *Austria.*

K. K. Universitäts Sternwarte.

Longitude from Greenwich, $57^m\ 41^s.4$ E.
Latitude, 50° 5′ 18″.8 N.
Authority for latitude and longitude: AL. DAVID and J. BÖHM.
Directors: J. STEPPLING, 1751;
A. STRUADT, 1781;
A. DAVID, 1799;
A. BITTNER, 1836;
K. KREIL, 1845;
C. JELINEK, 1851;
J. G. BÖHM, 1855;
Dr. C. HORNSTEIN, *Professor of Astronomy*, 1872 (?)
Assistants: Dr. A. SEIDLER;
Dr. G. BECKA;
Dr. W. ROSICKY.

TYCHO BRAHE had some astronomical instruments temporarily mounted at Prague (1600–1601). The Observatory, properly so called, was not erected until 1751, in the Altstadt quarter, at the Collegium Clementinium, under the direction of the Jesuits.

INSTRUMENTS:

(*a*) *Meridian circle:* one; maker, CHR. STARKE (Mechanical workshop of the I. R. Polytechnic Institute in Vienna); diameter of circle, 36 inches; divided to 3′; read by 4 nonius to 2″; aperture of objective, 4 inches.

(*b*) *Meridian transit instruments:* maker, CHR. STARKE; aperture, 4 inches: (*b′*) maker, SCHRÖTTER; aperture of objective, 3 inches.

(*c*) *Equatorial instruments:* makers, C. A. STEINHEIL'S SONS, in Munich; aperture of objective, 6 inches; magnifying powers of eyepieces, 56, 84, 252, 420, 672. (*c′*) makers, UTZSCHNEIDER & FRAUNHOFER, Munich; aperture of objective, 3 inches.

(*d*) *Spectroscopes:* one; G. & S. MERZ, Munich; one small star spectroscope; makers, G. & S. MERZ, Munich.

(*f*) *Chronograph:* one; Dr. M. HIPPS, Neuchatel, maker.

(*g*) *Clocks:* mean time; makers, LEPAUTE, Paris; sidereal; makers, J. BOZEK, Prague.

(*h*) *Chronometer:* mean time; maker, BARRAUD.

(*i*) *Miscellaneous:* one sextant; maker, TYCHO BRAHE; one octant; maker, TYCHO BRAHE; one large (Hohen Kreis), by TROUGHTON, in London.

OBSERVATIONS DURING THE PAST YEAR (1880):

No astronomical observations were made during the year.

WORK PROPOSED FOR THE COMING YEAR (1881):

It will be impossible to make astronomical observations during the coming year.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR 1880:

Magnetische und Meteorologische Beobachtungen im Jahre 1879, 40ter Jahrgang, 4to, (vol. xviii of series).

ADDITIONAL INFORMATION:

The two meridian instruments (*a*) and (*b*) have not been used for half a century, for want of a suitable meridian room, and have been stored away in boxes.

The two equatorial instruments, (*c*) and (*c′*), though mounted, are not being used for observation purposes, owing to the absence of a movable cupola, but are employed in the lectures on practical astronomy.

No astronomical observations whatever can be made in the present condition of the old Observatory.

PULKOWA, *Russia.*

See *Poulkovo.*

QUEBEC, *Canada.*

Observatory.

Longitude from Greenwich, $4^h\ 44^m\ 49^s.3$ W.

Latitude, 46° 48′ 17″.3 N.

Director: E. D. ASHE, 1863.

Built in 1863 on Bonner's Hill, near Quebec.

QUITO, *Ecuador.*

Observatorio del Colegio Nacional.

Longitude from Greenwich, ——?
Latitude, ——?
Director: J. B. MENTON, 1874.
Founded in 1874.

RIO DE JANEIRO, *Brazil.*

Nautical Observatory.

Longitude from Greenwich, $2^h\ 52^m\ 41^s.41$ W.
Latitude, 22° 54′ 23″.8 S.
Directors: A. M. DE MELLS, 1850;
E. LIAIS, 1871.
Founded in 1780. Restored in 1871.

ROMA, *Italy.*

R. Osservatorio Astronomico del Collegio Romano.

Longitude from Greenwich, $49^m\ 54^s.7$ E.
Latitude, 41° 53′ 53″.7 N.
Directors: G. ASCLEPI, 1764;
G. CALANDRELLI, 1773;
S. DUMONCHEL, 1824;
F. DE VICO, 1838;
A. LECCHI, 1849;
G. S. FERRARI, 1878;
P. TACCHINI, 1879.

Before the establishment of a regular Observatory a succession of astronomers, more or less famous, made use of temporary accommodations. In the buildings of the old college CLAVIUS made observations with a zenithal sector in 1572, and following years. SCHEINER collected the materials for his famous *Rosa Ursina,* the printing of which was completed in 1630 at the new college, west of the Church of St. Ignatius. There, too, GOTTIGNIER and BORGONDIO made occasional observations. MAIRE observed the comet of 1844 at the English College. BOSCOVICH fixed himself in the principal hall of the Kircher Museum. Finally, ASCLEPI organized a permanent establishment in 1764; and in 1787 a square tower was built to accommodate the Observatory at the eastern angle of the College façade on via del Gesù. A new building was put up in 1853, having for substructure the enormous piles which had been intended to support the dome of the Church of St. Ignatius.

ROMA, *Italy*.

Observatory of the Capitol.

Longitude from Greenwich, ——?
Latitude, ——?
Directors: G. CALANDRELLI, 1824;
A. CONTI, 1827;
I. CALANDRELLI, 1841;
L. RESPEGHI, 1866.

Established in 1824 upon the east tower of the Capitol, which is built above the ancient Forum.

RUGBY, *England*.

Observatory of Rugby School.

Longitude from Greenwich, ——?
Latitude, ——?
Directors: J. M. WILSON, 1872;
G. M. SEABROKE, 1878.

Founded in 1872.

RUGBY, *England*.

Temple Observatory.

Longitude from Greenwich, ——?
Latitude, ——?
Director: J. M. WILSON.

SAN FERNANDO, *Spain*.

Instituto y Observatorio de Marina de San Fernando.

Longitude from Greenwich, $24^m\ 49^s.6$ W.
Latitude, 36° 27′ 41″.5 N.
Directors: R. ARMESTO, 1797;
J. O. CANELAS, 1798;
J. T. CERQUERO, 1825;
S. MONTOJO, 1851;
F. DE P. MARQUEZ, 1855;
C. PUJAZON, 1866.

An Observatory had been first established at Cadiz in 1753, upon an ancient Roman tower, but was soon abandoned, observations being made there only from 1773 to 1776, by TOFIÑO and VARELA. The new Observatory was built at San Fernando in 1797. This is the most southerly astronomical establishment in Europe. (Latitude 36° 28′.)

SANTIAGO, *Chile.*

Observatorio Nacional.

Longitude from Greenwich, 4h 42m 42s.4 W.
Latitude, 33° 26′ 42″ S.
Directors: E. G. MAESTA, 1852;
J. I. VERGARA, 1861.

Proposed in 1852. The instruments and buildings which had been used for the temporary Naval Observatory of the United States at Santa Lucia, under Lieutenant GILLISS, were purchased as a beginning, and in 1856 the construction of a permanent Observatory was undertaken, consisting simply of a one-story edifice and central dome. The equipment has been added to gradually since 1859.

ST. PETERSBURG, *Russia.*

Observatoria Akademii Nauk. (*Observatory of the Academy of Sciences.*)

Longitude from Greenwich, 2h 1m 13s.5 E.
Latitude, 59° 56′ 29″.7 N.
Directors: J. N. DE L'ISLE, 1747;
P. INSCHODZOW, 1768;
R. BARRY, 1794;
V. WISNICROSKY, 1811;
A. SAWITSCH, 1856.

Founded in 1747.

SCHWERIN, *Germany.*

Sternwarte.

Longitude from Greenwich, 45m 40s.7 E.
Latitude, 53° 37′ 38″.2 N.
Director: ———?

SENFTENBERG, *Germany.*

Sternwarte.

Longitude from Greenwich, 1h 5m 50s.6 E.
Latitude, 50° 5′ 10″.1 N.
Director: ———?

SPEYER, *Bavaria*

Sternwarte des Königlichen Lyceum.

Longitude from Greenwich, $33^m\ 45^s.6$ E.
Latitude, 49° 18′ 55″.4 N.
(No longer in operation.)

STOCKHOLM, *Sweden.*

Observatory.

Longitude from Greenwich, $1^h\ 12^m\ 14^s$ E.
Latitude 59° 20′ 33″ N.
Directors: P. V. WARGENTIN, 1750;
H. NICANDER, 1776;
J. SOANBERG, 1803;
S. A. CRONSTRAND, 1828;
N. H. LELANDER, 1858;
HUGO GYLDÉN, 1871.
Assistants: AROID LINDHAGEN;
FREYOLD RANCKEN.

Founded in 1750. Here WARGENTIN made that long series of observations on Jupiter's satellites which resulted in the first reliable tables of eclipses of these satellites.

INSTRUMENTS:

(*a*) *Meridian circle:* makers, ERTEL & SON; diameter of circle, 18 inches; divided to 3′; read by 4 microscopes to 1″; aperture of objective, 4½ inches (0.107 meters); magnifying power ordinarily employed, 124 diameters.

(*b*) *Meridian transit instrument:* maker, A. REPSOLD; aperture, 2½ inches.

(*c*) *Equatorial instrument:* maker, A. REPSOLD; aperture of objective, 7 inches; magnifying powers of eye-pieces, 114, 150, 190, 302, 600.

(*f*) *Chronographs:* two.

(*g*) *Clocks:* mean time; makers, MOLYNEUX & COPE; sidereal; makers, KESSELS, SWEDER.

(*h*) *Chronometer:* mean time; makers, DENT, LINDEROTH.

The following is a translation of portions of a report made by Mr. HUGO GYLDÉN in the "Vierteljahrsschrift der Astronomischen Gesellschaft," 15ter Jahrgang, 2ter Heft:

Mention has been made in former reports of two extensive series of observations for the purpose of, firstly, to redetermine all the bright stars between 45° N. declination and the North Pole, which are accessible to our instruments; and, secondly, to furnish a contribution to the knowledge of the mean distances of stars.

This redetermination will result in the formation of a catalogue of 1,210 stars, in which the positions will be laid down with a probable error of about ¼ second in each co-ordinate (the rectascension probably more accurate). Most of the required observations were made by Mr. Lindhagen, and the series is nearly complete. The second series, unfortunately, will have to be delayed, owing to necessary repairs of the meridian circle, which exhibits traces of old age. - - -

From the results obtained by comparison in different positions, the the probable error of a single declination determination is estimated as 0″.5 to 0″.6, which may be still reduced.

Up to the present time the polar distances have been computed temporarily from observations of the Nautical Almanac stars, with application of the declination estimated in the fundamental catalogue for zone observations in the N. sky. Predominating, though not exclusive, use having been made of extreme northern stars, it is presumable that the unknown inclination of the instrument has exerted quite an influence on the results obtained. It is, however, evident from the coincidence of the polar positions obtained in both situations of the objective and ocular that the inclination coefficient, which appears as multiplied by the sine of the zenith distance, cannot be very large. - - -

The second series is intended to furnish a contribution to the knowledge of the mean distances of the stars. Mention of this work has been made in former reports, and an account of the progress made during the past year is here presented. •

Of the stars previously mentioned as to be observed for parallax, two have been omitted, namely, α Aurigæ, and ϑ Persei; the former on account of the difference of brilliancy between the principal star and a comparison star, the latter on account of the difference of declination of the comparison stars. These were substituted by α Coronæ, and ι Ursæ Majoris. In consequence of the brilliancy of the former the observations will be rather difficult and probably somewhat incorrect. I propose, however, to continue them for some time yet, in order to test whether the parallax may be confined to satisfactory limits by a multiplication of the observations. The same is the case with α Persei and β Andromedæ, notwithstanding their insufficient accuracy.

In observing ι Ursa Majoris use could be made of only one comparison star; a second one, at first designed to be included, proving too indistinct. The former, however, is in every respect satisfactory. This star moves on the same parallel with the principal star and 50½ seconds ahead, and its magnitude, according to Argelander, is 8.0. The considerable brilliancy of this star admits of its observation even during unfavorable state of the atmosphere, and it has not been neglected notwithstanding the sometimes very unsatisfactory impression obtained.

It is thereby intended to arrive at another result in addition to the determination of the parallax, namely, the collecting of material for the estimation of the relative accuracy which may be expected at the contact of the cross-wire and right-ascension differences during a favorable or unfavorable condition of the atmosphere. Although the results obtained, until now, in reference thereto are not by any means conclusive, they are regarded as worth communicating.

As the results of observations are computed, with but few exceptions, from four transits, the probable error ± $0^{s}.017$ is to be expected. In close conformity there is deduced from the 16 observations of ι Ursa extant at present the probable error ± $0^{s}.016$.

This result appears to be very satisfactory. Even if the probable error of a result of observations were ± $0^{s}.020$, 30 or 40 nights adequately distributed would be sufficient to determine the parallax of a star with a probable error of about ± 0″.035. If we confine ourselves to the observation of such stars, the star of comparison of which is neither too feeble or too distant, the observations may be made very rapidly without fatiguing the eye, so that a considerable number of stars can be compared in one night. There are several hundred pairs of stars in the heavens available for the purpose, and it does not seem therefore at all impracticable for several observers to take up the matter of settling upon a direct determination of the parallax of stars of the sixth magnitude, in which the probable error would amount to only about ± 0″.003. The medium parallax of these stars is, according to Peters, 0″.027, but probably is only one-half of this. Both magnitudes, as also their difference, are so much above the probable errors that it is to be hoped that conjectures on this important point will, at no distant time, be no longer necessary.

STONYHURST COLLEGE (near WHALLEY), *England.*

Stonyhurst College Observatory.

Longitude from Greenwich, $9^m\ 52^s.68$ W.

Latitude, 53° 50′ 40″ N.

Authority for latitude and longitude: Nautical Almanac.

Directors: A. WELD, 1838;
Rev. S. J. PERRY, S. J., F. R. S.

Assistants: M. M. W. CARLISLE;
W. MCKEON;
J. ROONSY;
J. CULLEN.

Location: Four miles W. of Whalley, Lancashire, England. Height above sea, 381 feet. Built in 1838 in the park of the Jesuit College.

INSTRUMENTS:

(*a*) *Meridian circle:* by Jones, 2 feet 6 inches; divided to 5′; microscopes reading to 1″; aperture of object glass, 3 inches; power generally used, 56.

(*b*) *Transit Instrument:* aperture of object glass, 2 inches $\frac{5}{8}$; power generally used, 42; by CARY.

(*c*) *Equatorial instruments:* one by NAPIER, CURRY, TROUGHTON & SIMMS; aperture, 8 inches; powers from 30 to 600 or 700: one by JONES; aperture, 4 inches. (*c*) A CASSEGRAIN reflector; aperture $9\frac{1}{2}$ inches; two, NEWTONIAN; aperture, 7 inches.

(*d*) *Spectroscopes:* an automatic instrument by BROWNING, 6 prisms of 60°, each used twice, with an half prism, making largest dispersion = 36 prisms of 60°. A large star spectroscope by SIMMS, 4 compound prisms by HOFFMAN. A large direct vision spectroscope by BROWNING. Two smaller instruments by BROWNING.

(*f*) *Chronograph:* small one by BREGUET.

(*g*) *Clocks:* two sidereal, mercurial pendulums.

(*h*) *Chronometer:* FRODSHAM, No. 3148.

(*i*) *Miscellaneous:* A couple of self-recording meteorological and magnetical instruments are in constant use.

OBSERVATIONS OF 1880:

Jupiter's satellites, lunar occultations, daily examination of chromosphere and solar spots, systematic search for ultra-Neptunian planet.

WORK FOR 1881:

Continuation of the same observations.

PRINCIPAL PUBLICATIONS IN 1880:

Results of Meteorological and Magnetical Observations, 1879.
Astronomical results appear in the monthly notices of R. A. S.
Meteorological results published by the Board of Trade.

STRASSBURG, *Germany*.

Sternwarte.

Longitude from Greenwich, $31^m\ 2^s.49$ E. } *Of the Old Observatory.*
Latitude, 48° 34′ 53″.8 N. }
Longitude from Greenwich, $31^m\ 4^s.65$ E. } *Of the New Observatory.*
Latitude, 48° 34′ 59″.7 N. }
Director: A. WINNECKE, 1875.

About 1770 some astronomical instruments were placed above the gate of the hospital. In 1804 J. HENRY established a small Observatory in the Münster (Cathedral), and observations were made there in 1824. A regular Observatory was not established by the city until 1836, and then it was placed under the charge of LEQUIANTE, but almost immediately abandoned. In 1873 a new Observatory was erected without the town, in connection with the University. Its general plan is a quadrilateral.

SYDNEY, *New South Wales*.

Government Observatory.

Longitude from Greenwich, $10^h\ 4^m\ 50^s.6$ E.
Latitude, 33° 51′ 41″.1 S.
Directors: W. SCOTT, 1856;
G. R. SMALLEY, 1862;
H. C. RUSSELL, 1870.

Proposed in 1855, completed in 1858. Its first instruments, supplied from the private Observatory which BRISBANE had established at Paramatta, were those by means of which DUNLAP had made his catalogues of double stars and of Southern Nebulæ. This establishment owns a refractor with an aperture of 11 inches (0^m. 28).

TASHKENT, *Russia.*

(*Turkestan Military District.*)

Observatoria.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

TOKIO, *Japan.*

Observatory of the Dai-Gaku.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: Prof. H. M. PAUL.

TORINO, *Italy.*

Regio Osservatorio dell Università.

Longitude from Greenwich, $30^m\ 48^s.4$ E.
Latitude, 45° 4′ 6″ N.
Directors: G. B. BECCARIA, 1759;
T. VALPERGADI CALUSO, 1782;
A. M. VASSALI EANDI, 1806;
J. PLANA, 1811;
A. DORNA, 1865.

Established in 1759 in the top of a tower at the corner of Piazza Castello. The Academy of Sciences undertook its direction in 1790, and had a new Observatory built in the Palace of the Academy. In 1820 the establishment was transferred to a terrace of the Palazzo Madama. In 1865 the Observatory became an appendage of the University.

TOULOUSE, *France.*

Observatoire.

Longitude from Greenwich, $5^m\ 51^s.1$ E.
Latitude, 43° 36′ 47″ N.
Directors: F. P. A. DE GARIPUY, 1775;
A. DARQUIER DE PELLEPOIX, 1782;
J. VIDAL, 1791;
MARQUÉ VICTOR, 1820;
F. PETIT, 1839;
F. TISSERAND, 1866;
B. BAILLAUD, 1879.

In 1748 DARQUIER began to make observations at Toulouse. The Observatory was established in 1775 at the Lyceum. A new structure was built in 1840 at the extremity of the city.

TREVANDRUM, *India.*

Trevandrum Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

TRIESTE, *Austria.*

Sternwarte.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Directors: F. SCHAUB, 1857;
A. KUNES, 1870.

TURIN, *Italy.*

See *Torino.*

TURNBRIDGE WELLS, *England.*

Crowborough Beacon Observatory.

Longitude from Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

TWICKENHAM, *England.*

Twickenham Observatory.

Longitude from Greenwich, $1^m\ 13^s.1$ W.
Latitude, $51^\circ\ 27'\ 4''.2$ N.
Director: ——— ?

UPSALA, *Sweden.*

Observatory of the University.

Longitude from Greenwich, $1^h\ 10^m\ 30^s.6$ E.
Latitude, $59^\circ\ 51'\ 31''.5$ N.
Directors: A. CELSIUS, 1730;
F. MALTET, 1757;
E. PROSPERIN, 1773;

Dr. MELANDERHJELM, 1796;
——— BERGSTRÖM, 1810;
N. H. LELANDER, 1852;
G. SWANBERG, 1858;
HERMAN SCHULTZ, 1864.

Founded in 1730.

The director has furnished the following particulars from his report for 1878–1879:

The most noteworthy occurrence during the past year is the setting apart, as an independent establishment, of the meteorological Observatory. This new arrangement, made practicable by a government appropriation for the current expenses, is as yet in so far incomplete as in absence of an independent building for meteorological purposes the institute occupies two rooms in the astronomic building. - - -

The requirements of the Observatory have been constantly increasing and are now imperative as regards instruments, repairs, and proper arrangements, if any kind of activity is expected. The present means are quite insufficient to satisfy the most urgent needs of the establishment.

The only room of observation in a satisfactory condition is the small Wackerbarth cupola, which was repaired last summer, while the meridian room and the large cupola require considerable repairs and improvements. - - -

The small collection of instruments of this Observatory, apart from quite antique instruments, consists of the following:

One parallactic refractor, made by STEINHEIL, 9 inches aperture, the principal instrument of the Observatory, the application of which, however, on account of insufficient mounting, is impracticable and limited. It has been employed mainly for observation of nebulæ and star clusters. A concise description of this instrument was given in the "Mikrometrisk Bestämning af 104 Stjerner inom Teleskopiska Stjerngrupper 20 Vulpeculæ."

One small parallactic refractor of 4 inches aperture, made by SIMS, in good condition, and presented to the Observatory some years ago by Prof. WACKERBARTH.

One old universal instrument of 45 millimeters aperture, by REPSOLD, the circles of which, however, are useless for practical measurements; it has been employed for many years for time determinations in the meridian.

One universal instrument 33 millimeters aperture, by MEYERSTEIN.

One small transit instrument 54 millimeters aperture, by STEINHEIL, the application of which is excellent, but which, on account of insufficient mounting, and too small meridian aperture (the telescope is affixed to the end of the axis of rotation), has thus far not found any proper application.

A small reflex circle by PISTOR, in satisfactory condition.

Four portable telescopes.

One old pendulum clock, by GRAHAM, reconstructed by KESSELS, about forty years ago.

Two old box chronometers, by KESSELS.

One portable barometer, by PISTOR.

The only instrument purchased during the past year is an inexpensive pendulum clock for experiments with electrical apparatus, though order was given for a registering apparatus for transit observation, and for three electrical clock attachments, to be employed in the small isolated pavilion.

In the total absence of an instrument for measuring zenith distances, preliminary communication has been held with the celebrated firm of REPSOLD SÖHNE, in Hamburg, for the preparation of a medium sized vertical circle. Further projects for the equipment of the Observatory have to be delayed for the present.

The WACKERBARTH reflector and the REPSOLD universal instruments have undergone repairs, and results in the improvement of the latter for transit observation. The STEINHEIL transit instrument is at present in the hands of Mr. Rose, maker to the University, for repair, having in view its application in the vertical of the Pole star.

The library of the Observatory originated by private donations, has received its principal increase in voluntary contributions by scientists and institutions abroad. It consists of four distinct groups: the HJORTER and MALLET donation, the Collectio Recentior and the Svanberg collections. The catalogue shows for these four the following figures, respectively: 1150, 880, 360, and 1200, of which, however, many, such as journals, annuals, ephemerides, &c., consist of a large number of volumes. On occasion of the emancipation of the meteorology, the works relating to this branch were set apart for that institute. The increase during the past year amounted to 90 contributions, of which 70 came from abroad; sixty books were bound.

In consequence of the circumstances referred to, little scientific work has been done during the past year. The director has continued his observations on nebulæ, while the assistant made time determinations. The director's time has been largely consumed in perfecting arrangements for instruction. Very desirable text-books have been published at government expense, and preparations made to facilitate astronomical instruction for the students, among which is the establishment of a work-room, in which opportunity is given to the students to acquaint themselves between the observations with recent astronomical literature and journals.

Eight students have practiced during the year, and many have attended the astronomical lectures.

UTRECHT, *Holland.*

Observatorium.

Longitude from Greenwich, $20^{m}\ 31^{s}.7$ E.
Latitude, 52° 5′ 10″.5 N.
Directors: J. F. HEUNERT, 1767;
G. MALL, 1812;
R. VAN REES, 1836;
M. HOEK, 1860;
J. A. C. OUDEMANS, 1874.

Founded in 1767. Remodeled in 1864. This Observatory possesses an altazimuth.

VALENCIA, *Ireland.*

Observatory of the London Meteorological Office.

Longitude from Greenwich ——— ?
Latitude ——— ?
Director: ——— ?

VARSHAVA *Russia.*

Astronomicheskaia Observatoria.

Longitude from Greenwich, 1h 24m 7s.4 E.
Latitude, 52° 13′ 5″.7 N.
Directors: ——— ARMINSKI, 1820;
J. D. BARANOWAKI, 1848;
J. WASTOKOFF, 1877.

In 1764 ROSTAN made observations at the Castle. From 1765 to 1768 N. WOLF made observations at the Blue Palace on the Mniczek. The Observatory was not established permanently until 1820, and the expenses of construction were met by STRASZIE, president of the University. It contains a hall for meridian instruments, and two towers with cupolas.

VENICE, *Italy.*

Observatory of the Naval Institute.

Longitude from Greenwich, 49m 25s.4 E.
Latitude, 45° 25′ 49″.5 N.
Directors: B. VON WÜLLERSTORF-URBAIR, 1840;
E. MILLOSEVICH, 1874.
Established about 1840.

VIENNA, *Austria.*

See *Wien.*

VILNA, *Russia.*

Astronomicheskaia Observatoria.

Longitude from Greenwich, 1h 41m 11s.9 E.
Latitude, 54° 41m N.
Authority for latitude and longitude: SLAVINSKI: "Astronomische Nachrichten," vol. v, and viii.
Directors: M. O. POCZOBUT, 1764;
J. B. VON SNIADECKI, 1808;

P. SLAVINSKI, 1824;
M. KLOUSCHNEVITCH, 1841;
G. A. VON FUSS, 1848;
G. SABLER, 1854;
Colonel PETER MYSLOFF, 1867.

Assistant: FRIED. WILHELM BERG.

It seems that this Observatory had already existed for some time, when in 1764 POCZOBUT restored it and replaced its instruments. Its labors, suspended during the Revolution, were not resumed until 1802.

INSTRUMENTS:

(*b*) *Meridian transit instrument:* maker, RAMSDEN, in 1777; aperture, 4 inches; magnifying power, 40 diameters.

(*c*) *Equatorial instrument:* maker, RAMSDEN, in 1777; aperture of objective, 4 inches; magnifying powers of eye-pieces, 40 and 60.

(*d*) *Spectroscope:* direct vision, maker, S. MERZ, at Munich.

(*e*) *Photometer:* made by the late Prof. L. SCHWERD, at Speyer. Of the three made by him one is in Bonn, and the other in Pulkowa.

(*f*) *Chronograph:* maker, ANSFELD, at Gotha.

(*g*) *Clocks:* one, mean time, maker, SHELTON, (London); one sidereal, maker, HARDY, (London, 1819).

(*h*) *Chronometer:* one, mean time, maker, DENT, No. 2796; one, sidereal, maker, DENT, No. 2000.

(*i*) A Heliostat, by S. MERZ. Various ancient astronomical instruments, and modern meteorological instruments. The library of the Observatory contains 1,966 works, in 4,181 volumes.

OBSERVATIONS:

From 1869 to 1876, photoheliographical observations, in the same manner as at Kew, near London. In the year 1876, the heliograph, by DALLMEYER, London, was destroyed by fire. Meteorological observations are made four times a day: at 7^h A. M., 1^h P. M., 9^h P. M., and 1^h 49^m P. M. ($=7^h$ mean Washington time, A. M).

WARSAW, *Russia.*

See *Varshava.*

WELLINGTON, *New Zealand.*

Government Observatory.

Longitude from Greenwich, ——?
Latitude, ——?
Director: ——?

WHALLEY, *England.*

See *Stonyhurst.*

WIEN, near, (WÄHRING,) *Austria.*

K. K. Universitäts Sternwarte.

Longitude from Greenwich, $1^h\ 5^m\ 21^s.49$ E.
Latitude, 48° 13′ 55″.4 N.
Directors: M. Kell, 1756;
F. von P. Friesnecker, 1792;
J. S. Bürg, 1817;
J. J. von Littrow, 1819;
K. L. von Littrow, 1841;
Prof. Dr. Edmund Weiss.
Assistants: 1. Johann Palisa.
2. Dr. Johann Holetschek.
Aids: 1. Karl Zelbr;
2. Dr. J. v. Hepperger.

The first observations made in Vienna were undertaken in 1745 by the Jesuits, J. François and J. Liesgang. A permanent Observatory was founded in 1756. It was rebuilt from 1820 to 1826, and located among the University buildings. In 1874 a new establishment on a greatly enlarged scale was erected at Währing, outside the town, and completed in 1879. An equatorial of Grubb's, with a focus of 32 feet ($9^m.7$) and an aperture of 27 inches ($0^m.70$) is to occupy the great dome.

INSTRUMENTS:

(*a*) *Meridian circle:* made by Christian Starke, at Vienna, (after the example of the meridian circles of Reichenbach); diameter of circles, 36 inches; divided to 3′; read by four microscopes to single seconds; aperture of objective, 48 inches; magnifying power ordinarily employed 120 diameters.

(*b′*) *Prime vertical:* maker, Christian Starke; aperture, 50 inches; magnifying power, 120 diameters.

(*c*) *Equatorial instruments:* one, made by Alvan Clark & Sons; aperture of objective, 11¾ inches; magnifying powers of eye-pieces, up to 1200. (*c′*) One, made by Frauenhofer; aperture of objective, 6 inches; magnifying powers, up to 600.

(*d*) *Spectroscopes:* one small star spectroscope; one Zoellner's solar spectroscope.

(*g*) *Clocks:* two mean time; makers, Ulzschneider, at Munich; Vorauer, at Vienna; several sidereal; makers, Molyneux (London); Auch (Gotha); Graham (London); and a few, more or less accurate.

(*h*) *Chronometers:* mean time; maker, Arnold; sidereal, makers, Kessels, Molyneux.

(*i*) *Miscellaneous:* An equatorial with adaptation for various latitudes, the 6-inch objective by Steinheil, the mounting by Schäffler. Two

Google

refractors of 4-inch aperture; one of them not equatorially mounted. One equatorial of 3-inch aperture, adapted for various latitudes, objectives, by FRAUENHOFER. One equatorial of 3-inch aperture, by DOLLOND. One dialitic equatorial of PLÖSSEL, of 5 inches. One comet-seeker, of 6-inch aperture, and 4 feet focal length, by MERZ; mounted equatorially on the principle of VILLAREAU, by SCHNEIDER. One comet-seeker of 3-inch aperture by PLÖSSEL; one of 2½ inches, by STEINHEIL. Besides these, various smaller portable transit instruments, theodolites, sextants, &c.

OBSERVATIONS DURING THE PAST YEAR (1880—June, 1881):

(*a*) Adapting instrument to the new Observatory; not regularly in use. Mostly used for determination of clock error, &c.

(*b′*) The same remarks applicable.

(*c*) (*c′*) Observations made of asteroids and comets.

WORK PROPOSED FOR THE COMING YEAR (1881–1882):

Continuation of observations of asteroids and comets, with the two equatorials: Zone observations (re-observations of stars observed by SANTINI, between decl. 0° and 10°) with the meridian circle. If the large equatorial of 27 inches by H. GRUBB, at Dublin, can be mounted in due time, observations with it will be commenced at once; but the plan of operation is not yet settled.

PRINCIPAL PUBLICATIONS DURING THE YEAR (1880):

E. WEISS; "Annalen der K. K. Sternwarte in Wien," iii Folge, Bd. 29, Vienna, 1881; 1 vol., 226 pp.

E. WEISS; "Ueber die Bahn der Kometen 1843 (I), and 1880 (*b*)." *Akad. d. Wiss. in Wien*, 1880; 1 vol., 20 pp.

E. WEISS, "Ueber Berechnung der Differentialquotienten in stark excentrischen Bahnen." *Akad. d. Wiss. in Wien*, 1881; 1 vol., 11 pp.

J. HOLETSCHEK; "Bahnbestimmung des Planeten Peitho.". *Akad. d. Wiss. in Wien*, 1881; 1 vol., 15 pp.

ADDITIONAL INFORMATION:

The principal instrument of the Observatory will be an equatorial of 27-inch object-glass, and about 32 feet focal length, manufactured by HOWARD GRUBB at Dublin; but it is not yet out of the contractor's hands. The first Assistant, Mr. J. PALISA, re-discovered Juewa (139), February 23, 1881; and discovered asteroid (220) May 18, 1881.

WIEN, (*Josephstadt*,) *Austria*.

Observatory of the High School of Technology.

Longitude from Greenwich, $1^h\ 5^m\ 25^s.3$ E.

Latitude, 48° 12′ 53″.8 N.

Directors: J. HERR, 1865;
W. SINTER, 1870.

Founded in 1865 at the southwestern extremity of the city; completed in 1867.

WILHELMSHAVEN, *Germany.*

Kaiserliches Marine Observatorium.

Longitude from Greenwich, $32^{m}\ 35^{s}.21$ E.

Latitude, 53° 31′ 52″.2 N.

Authority for longitude: Astronomische Arbeiten des kgl. preuss. geodätischen Instituts für 1878. Latitude, own observations of zenith-stars with meridian circle.

Director: C. BÖRGEN, *Dr. phil.*, 1876;

Assistants: P. ANDRIES, *Dr. phil.;*

Lieutenant zur See, HARTMANN.

Founded in 1875; completed in 1878.

INSTRUMENTS:

(*a*) *Meridian circle:* one; makers, A. REPSOLD SÖHNE, in Hamburg; diameter of circles, 21.6 inches, divided to 2′; read by 4 microscopes, each to 0″.1; aperture of objective, 4½ inches; magnifying power ordinarily employed, 125 diameters.

(*b*) *Meridian transit instruments:* one portable, by C. BAMBERG, Berlin; aperture, 1½ inches.

(*c*) *Equatorial instruments:* one, by STEINHEIL SÖHNE, in Munich; aperture of objective, 4 inches; magnifying powers of eye-pieces, 48 to 360; ring-micrometer. (*c′*) One, STEINHEIL SÖHNE; 2½ inches aperture; magnifying power, 24 to 150.

(*f*) *Chronograph:* one, by FUESS, Berlin.

(*g*) *Clocks:* mean time; one, by EPPNER, Berlin; sidereal; one, by F. TIEDE, Berlin (standard clock).

(*i*) *Miscellaneous:* A complete set of LAMONT'S instruments for observing the variations of the magnetical declination, horizontal force, and inclination.

LAMONT'S magnetical theodolite; dip-circle by DOVER; self-registering barometer and anemometer (ROBINSON); meteorological instruments; self-registering tide-gauge; time-ball. Since September, 1880, a self-registering tide-gauge, devised by Mr. REITZ, of Hamburg, has been erected in Heligoland and placed under the control of this Observatory.

OBSERVATIONS DURING THE PAST YEAR (1880):

(*a*) Observations for time and determination of places of the occultation-stars of the Nautical Almanac.

(*b*) Only used for practical instruction.

(*c*) (*c′*) Comet Swift (1880 c). Occultations of stars.

(*i*) Meteorological observations (three times a day, usual weather recording and registering of barometer and anemometer, read hourly), magnetical observations; every second hour from 8 a. m. to 10 p. m. readings of the variation instruments, and every month one or two absolute determinations of magnetic elements. Tide registerings here and in Heligoland.

WORK PROPOSED FOR THE COMING YEAR (1881):

Same as 1880.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR 1880:

1. "Meteorologische Beobachtungen," published in the "Annalen der Hydrographie," vol. viii.

"Gezeiten Tafeln für 1881," published by the Hydrographic Office of the Admiralty.

3. Dr. BÖRGEN: "Gezeitenströmungen im Canal und der Nordsee," published in the "Annalen der Hydrographie," vol. viii.

4. Dr. BÖRGEN: "Ueber die tägliche Ungleichheit in den Gezeiten," published in the "Annalen der Hydrographie," vol. viii.

5. Dr. BÖRGEN: "Chronometer Untersuchungen, 1878–1880," published in the "Annalen der Hydrographie," vol. viii.

6. Dr. ANDRIES: "Ursache des niedrigen Luftdrucks auf der Südhemisphäre," published in the "Zeitschrift für Meteorologie," vol xv, p. 53.

ADDITIONAL INFORMATION:

A time-ball falls twice daily, in local and in Greenwich noon. Besides, the nautical school at Elsfleth receives twice a week telegraphic time-signals.

The "Gezeiten Tafeln" are computed at the Observatory and extend now to 7 German, 6 British, and 2 French ports. The second part, containing information about currents, &c., is worked out at the Hydrographic Office of the Admiralty, which publishes the whole.

WILLIAMSTOWN, *Victoria*.

Observatory. (See *Melbourne*.)

Longitude from Greenwich, 9h 39m 38s.8 E.
Latitude, 37° 52′ 7″.2 S.
Director: ——— ?

WILNA, *Russia*.

See *Vilna*.

WINDSOR, *New South Wales*.

Private Observatory.

Longitude from Greenwich, 10h 3m 21s.7 E.
Latitude, 33° 36′ 28″.9 S.
Director: JOHN TEBBUTT

ZI-KA-WEI, *China.*

Observatory.

Longitude for Greenwich, ——— ?
Latitude, ——— ?
Director: ——— ?

ZÜRICH, *Switzerland.*

Sternwarte des schweizerischen Polytechnikums.

Longitude from Greenwich, 34^m 12^s.6 E.
Latitude, 47° 22′ 40″ N.
Authority for latitude and longitude: Astronomische Mittheilungen von Dr. RUDOLF WOLF.

Directors: J. H. WASER, 1773;
J. FEER, 1787;
J. ESCHMANN, 1823;
RUDOLF WOLF, 1860;
Assistant: ALFRED WOLFER.

Founded in 1773 upon the Carolus Thurm (Charles' Tower), through the efforts of the Zürich Society of Naturalists. Abandoned from 1798 to 1805. In 1810 a new Observatory was erected east of the Carolus Thurm; this was abandoned in 1852. Finally in 1860 the Observatory was rebuilt at the Polytechnikum, where it was inaugurated in 1863.

INSTRUMENTS:

(*a*) *Meridian circles:* two; makers, KERN, in Aarau, ERTEL, in Munich; diameter of circles, 20 inches; divided to 2′; read by 2 microscopes to 0.1″; aperture of objective, 5.3 inches; magnifying power ordinarily employed, 120.80.

(*c*) *Equatorial instruments:* makers, KERN, in Aarau; aperture of objective, 6 inches; magnifying power of eye-pieces, 60 to 500. (*c′*) MERZ, in Munich, 3½ inches; 64 to 212.

(*d*) *Spectroscope:* one by MERZ, in Munich.

(*f*) *Chronographs:* four by HIPP, in Neuchatel, and HASSLER, in Aarau.

(*g*) *Clocks:* mean time; makers, Association ouvrière au Locle; sidereal; maker, SILVAIN MAIRET au Locle. Also several pendulum clocks, among which one by REPSOLD.

(*h*) *Chronometer:* sidereal; seconds chronometer; maker, BUZENGEIGER.

(*i*) *Miscellaneous:* Several astronomical theodolites, meteoroscopes, panagenprisms, &c.; also historical collection of antique instruments.

OBSERVATIONS DURING THE PAST YEAR (1880):

(*a*) Time determinations; refraction, &c.; moonstars.

(*c*) (*c′*) Sunspots; planets, &c.

(*i*) Shooting stars.

WORK PROPOSED FOR THE COMING YEAR (1881):

Continuation of former series.

PRINCIPAL PUBLICATIONS OF THE OBSERVATORY DURING THE YEAR (1880):

R. WOLF, Astronomische Mittheilungen, published in "Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich."

ADDITIONAL INFORMATION:

The Observatory of the Polytechnikum is mainly used for the practical training of the students. The scientific results are voluntary contributions by the director and assistant.

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